CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 39 OCTOBER, 1953 NUMBER 4

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CALIFORNIA FISH AND GAME

VOLUME 39 OCTOBER, 1953 NUMBER 4

Published Quarterly by the
CALIFORNIA DEPARTMENT OF FISH AND GAME
SACRAMENTO

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TUNA MARKING, A PROGRESS REPORT[1]

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INTRODUCTION

The past decade has seen the industry engaged in processing the tunas become the largest fishery industry of the State and, dollarwise, the most productive of any in the United States. This increase, with a consequent increase in the rate of exploitation of the tuna resource, has made ever more imperative the need for information upon which a stabilized yield can be based.

The California tuna industry is primarily dependent upon four species: yellowfin tuna (*Neothunnus macropterus*), skipjack (*Katsuwonis pelamis*), albacore (*Thunnus germo*), and bluefin tuna (*Thunnus saliens*). Yellowfin tuna and skipjack are essentially tropical in their distribution, and are the objects of a single year-round fishery by the tuna clipper and purse seine fleets. Albacore and bluefin tuna are mainly subtropical and temperate in their distribution and each is the object of a separate fishery.

It is a basic requirement to define the population units which are being exploited. Do the tuna taken on the various fishing grounds comprise a single intermingling unit, or are they composed of several partially intermingling or nonintermingling units? The solution of this problem may be approached in two ways. One approach is through comparison of body proportions and meristic counts of fish from the areas in question. Another is the marking of fish to determine migration patterns, if any. Obviously the former is the least expensive of the two, but it does not furnish the direct evidence that can be derived from marking.

The fishery for yellowfin tuna and skipjack has ranged increasingly southward, and in 1950-51 the tuna fleet made another significant advance to new grounds off the coast of South America. Consequently, it has become of increasing importance to check the interchange between the various fishing grounds and to obtain information concerning possible migration patterns. Accordingly, it was determined to attempt to mark tuna as the most direct approach to the question of interchange between the various fishing grounds.

The present experimental tagging program has developed a plastic tubelike tag which has been retained by yellowfin tuna up to 253 days, without observable damage to the fish.

EARLIER WORK

Morphometric

Godsil (1948, page 6) has, on the basis of a comparison of the body proportions of yellowfin tuna, presented the following general conclusions:

"1. The stock of yellowfin tuna now exploited in the Eastern Pacific by the California fleet, ranging from Southern California to the equator, consists of a single intermingling population.

[1] Submitted for publication June, 1953.

"2. The sample of yellowfin from Japan is, with a high degree of probability, separate and distinct from that of the Eastern Pacific.

"3. The sample of Hawaiian yellowfin indicates that this population is likewise distinct from our local fish, but is intermediate between the Japanese and American populations.

"4. The relationship of the Hawaiian to the Japanese populations cannot be determined from the present data, but the distribution of individual values suggests that these two populations are more closely related to one another than to the American stock.

"5. The Peruvian yellowfin are similar to the local population in four of the five proportions, but a suggestive difference exists in the fifth proportion. Until this apparent difference can be explored in a larger sample, the two populations should be regarded as distinct."

Further work by Godsil (1951), Schaefer (1952), and Royce (ms) reinforce Godsil's preliminary conclusion with respect to the differences between Hawaiian and Eastern Pacific yellowfin tuna.

Godsil (1948, page 26) also presented the following conclusions based upon a comparison of the body proportions of albacore:

"1. The local and Japanese populations of albacore are probably distinct and nonintermingling. The Japanese albacore are characterized by a relatively shorter head and caudal region, and a longer abdominal or central trunk.

"2. The Hawaiian albacore appear to resemble the Japanese more than the local fish, but a larger sample of more comparably-sized fish is needed to justify any conclusions."

So far, conclusions based on the body proportions or meristic counts of skipjack or bluefin tuna have not been presented.

Marking

Methods used in the past to mark tunas have not been notably successful, and there has been much variation in the tags used.

Probably the first marking of tuna was done by Sella, who in 1911 tagged 10 Mediterranean bluefin tuna, using a tag of copper chain around the caudal peduncle. No tagged fish were recovered. (Rounsefell and Kask, 1945.)

Based on the observation that bluefin tuna captured sometimes retained the hook of a previous victorious encounter with fishermen, Heldt in 1927 placed identifying marks on hooks used by French fishermen of the Isle of Groix. (Rounsefell and Kask, 1945.) Sella (1929) reported upon the migrations of Atlantic bluefin tuna, based upon the recovery of 39 hooks and leads lost by fishermen which could be identified as to origin. Between 1931 and 1935, Frade and Dentinho (1935) tagged 107 bluefin tuna in Portuguese waters, using two tags around the caudal peduncle, one a leather strap with a bronze plaque, the other a bronze strap. A few examples were marked also with a bronze tag affixed to the second dorsal fin. The same workers, in 1935, distributed marked hooks free to fishermen.

The Japanese, in 1934-38, tagged 2,230 skipjack, chiefly with a celluloid and silver wire tag affixed around the caudal peduncle. There were eight

recoveries, all taken within 58 days of release. They also tagged an unknown number of "small tuna," of which there were seven recoveries, but none of the fish were at liberty more than 6.4 days.

Godsil, in 1934-38 (1938), tagged 4,000 yellowfin tuna and skipjack and 70 albacore, using an opercular strap tag. A single yellowfin tuna was recaptured, one day after release.

Westman and Neville (1942), tagged 23 bluefin tuna in the vicinity of Long Island, New York. They used a pair of celluloid disks attached to the gill cover. Two of these fish were recaptured within two months of release. They did not discuss the effect of the tag on the fish recovered.

The Fisheries Research Board of Canada, in 1948, tagged 140 albacore with a button-type celluloid tag, with a nickel pin through the tail. In 1950 the same organization tagged 355 albacore with a specially designed hook tag. There have been no recoveries. (Scagel, 1949; Partlo, 1951.)

The United States Fish and Wildlife Service, in 1950, tagged 397 albacore with a Peterson-type tag affixed through the base of the second dorsal fin, and 35 albacore with a "plastic strip tag." There were no recoveries, but one fish was taken subsequently which bore indications of a tag having been torn off. The same organization tagged 42 albacore in 1951 and 147 in 1952, all with an experimental type streamer tag. There have been, to date, no recoveries. (Powell, et al., 1952; Schaefers, 1952; Com. Fish. Rev., 1952.)

PRESENT TAGGING METHODS

It was concluded, at the time that the present tag development program started in California (early 1952), that a suitable tag for marking tunas probably was not developed.

Several criteria were established prior to an attempt at tag development as follows:

1. The tag must be readily seen, preferably from either side while the fish is lying on deck. Tuna are generally handled individually several times before butchering and high visibility would keep recovery efficiency at a maximum.
2. The tag should not damage the fish or impair its movements to a point where its behavior might be different from that of an untagged fish.
3. The material of which the tag is made should be chemically inert and nontoxic.
4. The tag should be easily and rapidly applied.
5. The tag should be retained by the fish for a long period of time.

The work of Alverson and Chenowith (1951), who conducted water tunnel tests of fish tags on albacore, furnished a valuable foundation upon which an experimental program of tag development could be based.

Subsequently, nine tag "ideas" were developed, using some plastic materials not heretofore available to earlier workers (Figure 1). The hook tag was not considered because it was felt that the tag caused damage to the mouth parts of the fish, and the Peterson-type tag because of excessive shedding. Nor did the "ideas" include a strap or band around the caudal peduncle because the mackerel tagged in that manner by Sette, using a poultry leg band, caused most of the fish to become severely emaciated with bad chafing of the peduncle. (Rounsefell and Kask, 1945.)

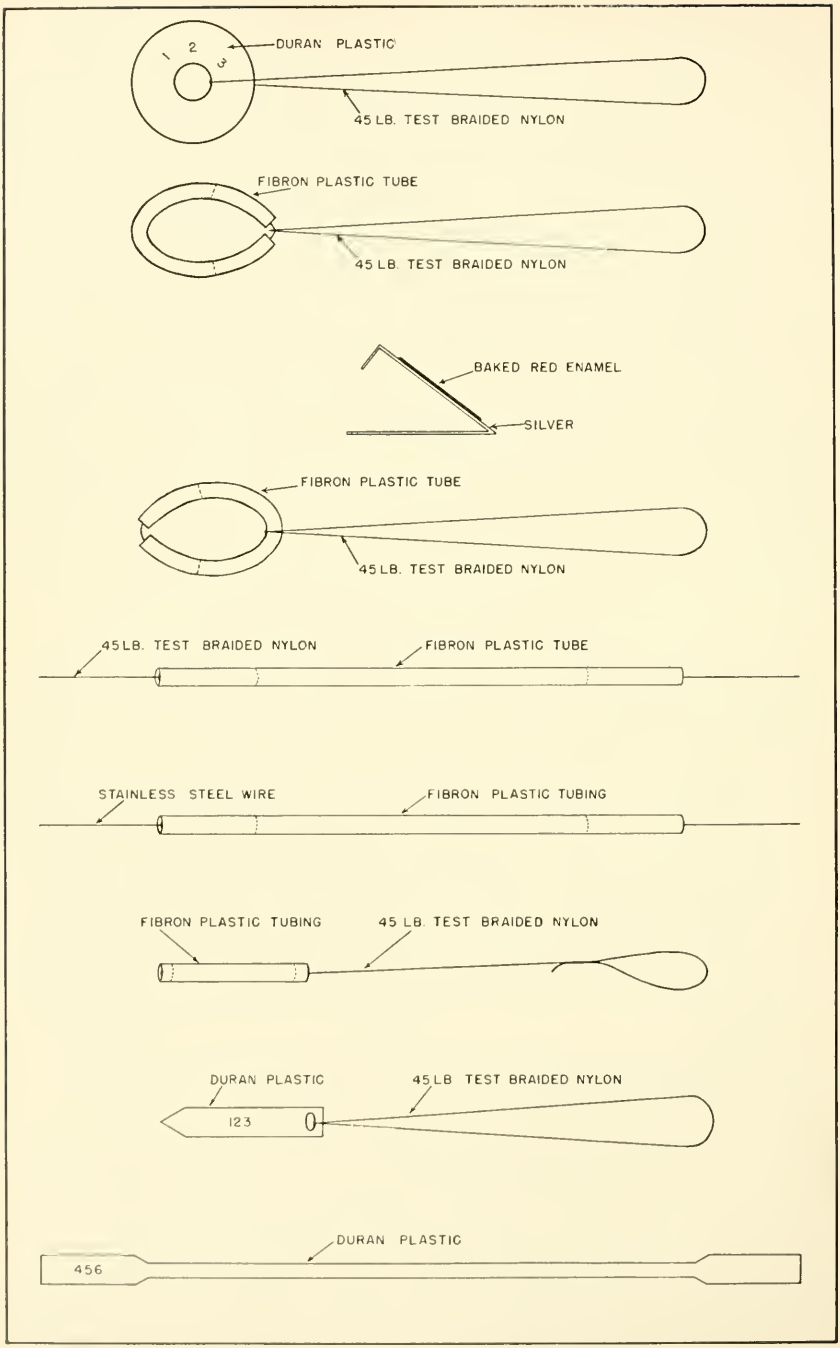

FIGURE 1. The nine tag ideas developed prior to the first field trial

THE FIRST FIELD TRIAL

Proper hydraulic facilities were not available for experimental testing of the proposed tags, nor were facilities available for a holding experiment with the tunas. Therefore, field trials of the tags were deemed the only feasible approach. At this stage, the number of experimental tags was reduced to the four believed most promising, as follows:

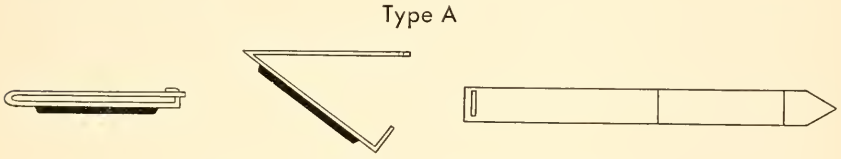

FIGURE 2. The Type A tag used in the first field trial

Type A is the silver strap tag developed by Godsil, but without the celluloid disk. Baked on the upper surface of the tag is red enamel. The identification number is stamped on the basal portion. It is snapped on the preoperculum with specially designed tagging pliers.

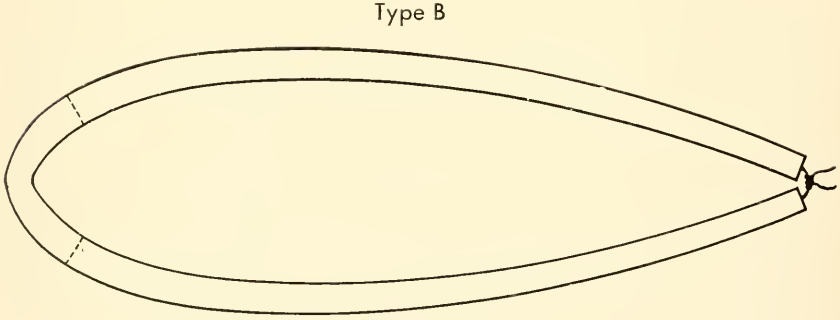

FIGURE 3. The Type B tag used in the first field trial

Type B is a tube of No. 14 Fibron, a polyethylene plastic manufactured by the Irvington Varnish and Insulator Company, Irvington 11, New Jersey. The plastic tube is formula XTE-30, outside diameter 0.098 inch, inside diameter 0.066 inch. The tube was cut in 30 cm. lengths. Colors used were blue and yellow. Through the center is 45-pound test-braided nylon fishing line, green in color, and tied in a double square knot. A paper legend for identification was inserted in the tube.

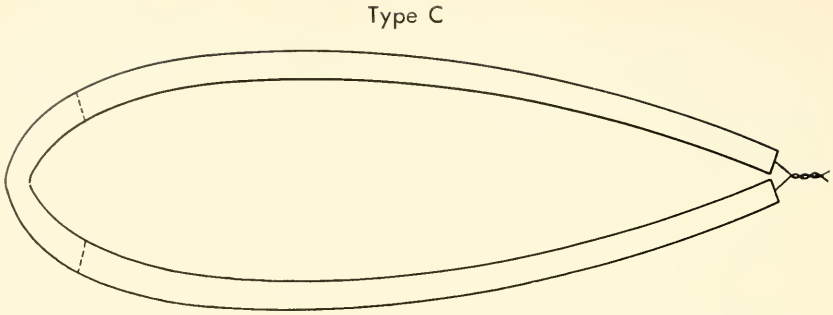

FIGURE 4. The Type C tag used in the first field trial

Type C is a No. 14 Fibron tube cut 20 cm. in length. Through the center is type 302 stainless steel wire 0.032 inch in diameter. The wire is a very malleable chrome-nickel stainless steel wire, obtained from the Ducommon Metals Company, Los Angeles, California. The wire is twisted as shown, and trimmed. A paper identification legend is inserted in the tube.

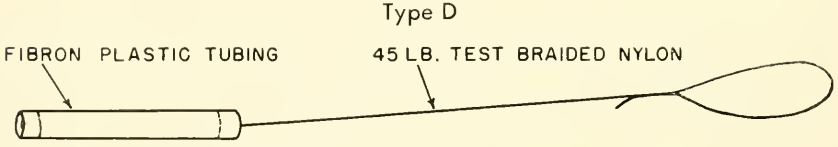

FIGURE 5. The Type D tag used in the first field trial

Type D is a streamer type tag using 45-pound test-braided nylon fishing line. The nylon length, not counting the loop, is 22 cm. Over the end opposite the loop is a 2.5 cm. piece of No. 14 Fibron, blue in color. A paper legend is inserted and the entire "tail assembly" is dipped in Cleroplast, a liquid plastic which sets hard, forming a single unit.

It was decided to affix all of the streamer-type tags through the flesh of the back just posterior to the second dorsal fin but anterior to the first finlet. An alternative location, through the flesh of the ventral surface just posterior to the anal opening, was considered, but the dorsal surface was selected because the tag could be attached more easily in that location. The opercular strap tag was to be affixed through the preopercului.

The first field trial consisted of two cruises by the department's research vessel N. B. Scofield into Mexican waters in early 1952. Some of the fish were caught by trolling, but most were taken using conventional tuna bait-fishing methods. There were four recoveries from 350 tagged yellowfin tuna. Only one skipjack was tagged.

TABLE 1
Summary of Releases and Recoveries, First Field Trial

Tag type and color	Yellowfin tuna			Skipjack
	Number tagged	Recoveries	Days out	Number tagged
Type A	1	0	—	0
Type B (blue)	15	2	74 and 105	0
Type B (yellow)	24	1	107	1
Type C (blue)	42	1	9	0
Type C (yellow)	125	0	—	0
Type D (blue)	33	0	—	0
Type D (yellow)	110	0	—	0
Totals	350	4	—	1

The Type A tag was abandoned early in the first field trial because of technical difficulties in its application.

Subsequent to the recovery of the four tagged yellowfin tuna, certain conclusions were reached:

1. That the Type B and C tag showed promise.
   a. In each of the four recoveries the tag was seen by fishermen before the fish were unloaded and not in later cannery handling.
   b. It was not felt, from observation of the condition of the fish recovered, that the tag damaged the fish or impaired its movements substantially. The wound where the tag was inserted was in all cases healing, and in the cases of the three tags out over 70 days, new skin was being regenerated in the outer portions of the wound. Wear was observed on a finlet of one of the recovered fish where the end of the tag loop had rested against it.
   c. There was no observable deterioration in the plastic of which the tags were made, with the exception that the yellow color had leached out in the single yellow plastic return. Some wear was observed in the braided nylon fishing line and the green color was leached out. No change was observed in the stainless steel wire.
2. That the Type A and D tag should be abandoned. The work of Alverson and Chenowith (1951) suggests that tag shedding is probably excessive in the case of the opercular strap tag; also, the tag is visible from one side of the fish only and is not as easily seen by fishermen. While there is no positive evidence, it was felt that tag loss of the Type D was probably much greater than that of the Type B or C because of the greater bearing surface of the latter in the tissues through which it is affixed.
3. That a modification was necessary to provide a permanent readable legend. The paper identification legends in three cases out of four were unreadable because the paper had deteriorated.

THE SECOND FIELD TRIAL

Based on the conclusions of the first field trial, the tags were modified. Also, another modification of the Type B-C idea was added and the second field trial was begun, using three types of tags.

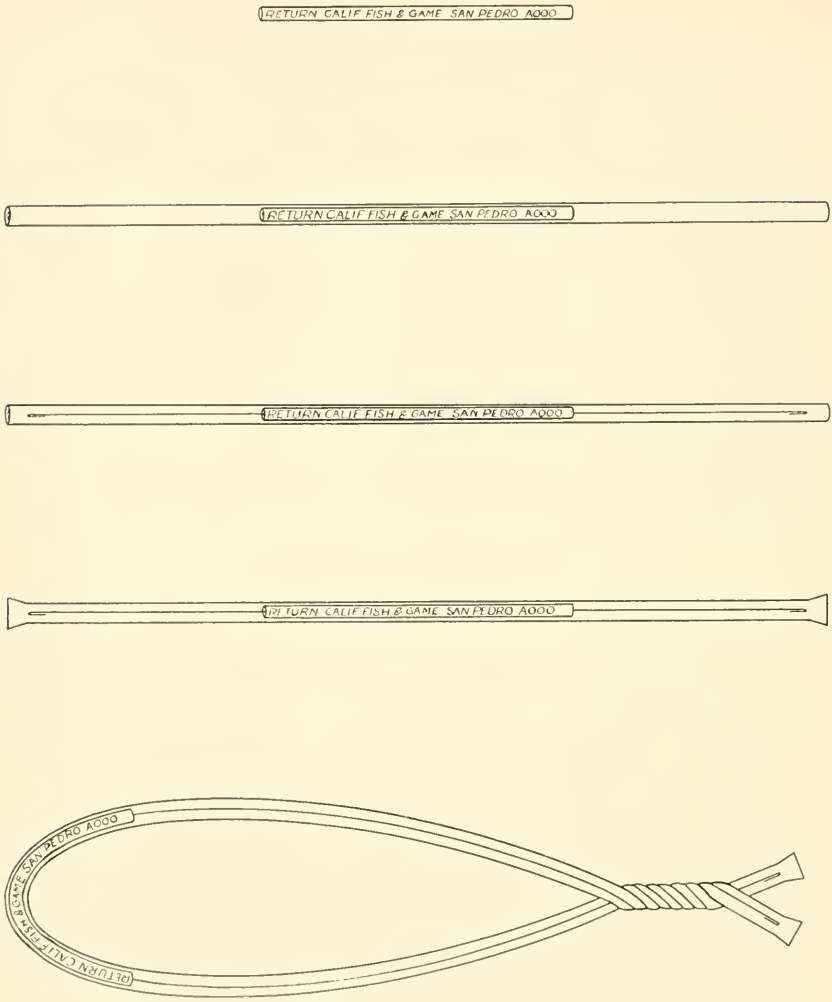

FIGURE 6. Steps in the manufacture of the Type E tog used in the second field trial

Type E

Type E is a modification of Type C. The tag is constructed of a piece of number 20 white Fibron tubing cut 7 cm. in length. Upon this is inscribed the legend in black vinylite ink, obtained from the California Ink Company, Los Angeles, formula number 104N5A2. The tubing bearing the legend is drawn into a piece of number 14 XTE-30 colored Fibron tubing cut 30 cm. in length. The transparency of the colored Fibron permits the legend to be read through the outside tube. Through the tubing is then drawn a piece of type 302 stainless steel wire and the ends of the wire are bent over 1 cm. at each end. The ends of the tag are then heat welded, using an electric iron.

Type F

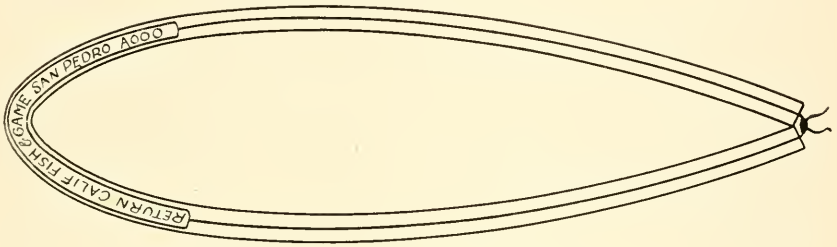

FIGURE 7. The Type F tag used in the second field trial

Type F is a modification of Type B, using the same style legend as Type E. Through the tubing is run 27-pound test-braided nylon fishing line, which is tied in a double square knot when applied.

Type G

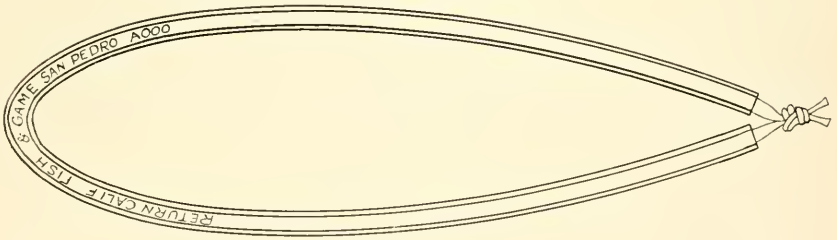

FIGURE 8. The Type G tag used in the second field trial

The outside tubing of the Type G tag is number 14XTE-30 Fibron cut 22 cm. in length. Through this is run a piece of number 20 white XTE-30 Fibron tubing cut 46 cm. in length. The legend is printed at about the center of the inside tubing. When applied, the white tubing is tied in a double figure eight knot, drawn tight, and about 7 cm. trimmed off the ends.

As of June, 1953, a total of 2,412 tunas of three species have been tagged in the second field trial using the Type E, F, and G tags.

TABLE 2
Summary of Releases and Recoveries, Second Field Trial

Tag type and color	Yellowfin tuna			Albacore			Skipjack	
	No. tagged	Recovered	Days out	No. tagged	Recovery	Days out	No. tagged	Recovery
Type E (blue)	43	2	37, 253	75	0	—	33	0
Type E (red)	309	0	—	0	—	—	153	0
Type F (blue)	161	0	—	83	0	—	81	0
Type F (yellow)	430	1	32	0	—	—	150	0
Type F (clear)	76	0	—	0	—	—	50	0
Type G (blue)	484	7	18,28,29 30,34,38 204	65	2	29 & 42	196	0
Type G (clear)	97	0	—	0	—	—	26	0
Totals	1600	10	—	223	2	—	589	0

To date (June, 1953), all of the tags recovered in the second field trial have been observed by fishermen. Of the total of 12 recoveries, 9 of the tuna "bit again"; 7 of the yellowfin tuna recovered were taken by hook and line and the two albacore by trolling.

In all of the tag recoveries where the fish was observed, the wound was either partially or completely healed. In the case of the yellowfin tuna that was at liberty 204 days before recapture, new skin had been regenerated completely through the tag insertion hole, even though the hole was enlarged to about three times its original diameter. (Figure 9.)

There appears to be no deterioration of the plastic material of which the tags are made. It was feared, in the case of the Type G tag, that the plastic would become brittle and break at the knot after long periods in the water. There was no such brittleness observed in the case of the Type G tag which was out 204 days.

In the second field trial all of the albacore were tagged from a chartered vessel, the Ocean Boy, in August, 1952. The yellowfin tuna and skipjack were tagged from two additional cruises of the N. B. Scofield and from two commercial tuna vessels, M. V. Intrepid and M. V. Southern Pacific. Yellowfin and skipjack tagging from tuna clippers has proven much less expensive than from the state-owned vessel. A tagging crew of two biologists is adequate for the tagging from commercial vessels. Through the courtesy of the American Tuna Boat Association, the vessel donates the fish tagged and in turn the biologists of the tagging crew assist in vessel operations, except when fish are coming aboard.

FIGURE 9. Closeup of the tag insertian hole in o yellowfin tuna. The fish was at liberty 204 days before recapture. The tag hos been flipped forward to better show the condition of the hole. The shiny black area of the hole is new skin. The damoge to the second dorsal fin was caused by handling in recapture. *Photograph by Leo Pinkas, May, 1953.*

TAG APPLICATION METHODS

Critical to any tagging program is the removal of the fish from the water, affixing a tag, and return to the water with a minimum of ensuing mortality. Earlier workers have demonstrated that at least some of the tuna that were tagged survived the process.

At the outset of the first field trial, it was considered necessary to obtain a measurement of the length of the fish. A suitable scale for such measurement was considered to be the nearest half-centimeter. The reason for desiring a measurement is that the rate of growth of the Eastern Pacific tunas has not as yet been worked out completely and the size change of tagged fish might provide valuable information on this problem. In order

to obtain a measurement, a tagging cradle of hollowed-out oak with a metric scale set in the bottom was used in the first field trial. A later improvement was a tagging cradle with sponge rubber sides and a dural scale with a rider set in the bottom. This decreases damage to the fish while it is being held for measurement and provides more accuracy in measurement. (Figure 10.)

FIGURE 10. Tuna tagging aboard M. V. N. B. SCOFIELD May, 1953. The yellowfin tuna has been measured and the measurement recorded by the recorder in the background. Measurement is effected by holding the nose of the fish against the head of the tagging cradle, and bringing the rider on the scale in the "V" of the tagging cradle against the fork of the tail. The tag has been inserted and the tag number checked against the number on the record. The tag has been knotted and trimmed, and the fish is ready for release. Note the tag holder between the tagging cradles. The fish when brought aboard are nat dropped on deck, but dropped into the canvas cradle just aft of the tagging cradles. The "fish holder" is holding his left hand lightly over the eyes of the fish. *Photograph by C. R. Clothier.*

A plastic tag holder with a capacity of 100 tags was developed. One can be seen between the tagging cradles in Figure 10. Using tag holders, the tags for a cruise can be preloaded, and the accompanying data sheets set up in advance. When a recorder is available, as aboard M. V. N. B. Scofield, the data sheets are of paper. Aboard commercial vessels no recorder is available, and waterproof plastic recording sheets are used.

A stainless steel tube is used as a needle for piercing the back of the fish. The inside diameter of the tube is such that the end of the tag rides inside the tube. When the needle is inserted, the end of the tag is carried through with it.

All of the tunas are very vigorous fish, and when one is brought aboard, it will go into a flurry of vibration which ends in a severe hemorrhaging from the gills. However, if the fish are seized within a few seconds after being brought aboard, most will lie, for a time, flexed in the tagging cradle without fighting, and can be thus measured and tagged without serious

FIGURE 11. Inserting a Type F tag on a small yellowfin tuna. The tag insertion needle shown is too long when used on small fish, because the needle rides into the side of the cradle. The tag insertion needles have since been made shorter. *Photograph by C. E. Blunt, Jr., May, 1953.*

damage. One hand held lightly over the eyes of the fish assists materially in keeping the fish quiet. Yellowfin tuna are the easiest to handle of the three species tagged. Skipjack are very hard to handle and the fish must be tagged within a few seconds of capture, or be damaged severely. Albacore are more difficult to handle than are yellowfin tuna, but probably are not so easily damaged as are skipjack.

FUTURE PLANS

It is planned to continue the second field trial until early 1954, at which time it is hoped that enough long-range returns will be on hand to provide a basis for discontinuance of the second field trial, and establishment of a program to determine the migrations of the three tunas in question.

ACKNOWLEDGMENTS

A program of tag development such as this one is necessarily based on the experience of earlier workers, combined with utilization of materials not available to them, and extended into ideas for future experiment. Mr. E. C. Greenhood, assisted by Mr. H. B. Clemens, developed the first tags used in this program, and Mr. Greenhood was in charge of the first cruise of the first field trial. Mr. C. E. Blunt, Jr., was in charge of three subsequent cruises and contributed materially, as did Mr. Clemens and Mr. David Ganssle, who were in charge of the two cruises aboard commercial tuna clippers.

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CALIFORNIA-TAGGED ALBACORE RECOVERED OFF JAPAN

The first authentic record of transpacific migration by an albacore (*Thunnus germo*) was obtained by the California Department of Fish and Game in July, 1953, through the return of a tag from Japan. Fishermen aboard No. 5, Chesho Maru of Mie Prefecture noticed the fish when it was caught on hook and line at latitude 31° 30′ N., longitude 149° 40′ E., 550 miles southeast of Tokyo, on June 23, 1953. This fish was one of 215 albacore tagged by the Department of Fish and Game during the month of August, 1952.

The fish was tagged on August 4, 1952, at latitude 33° 25′ N., longitude 118° 15′ W., 18 miles south of Los Angeles Harbor, California. It had moved 4,900 miles west and had been out 324 days since the time of tagging. (The great circle distance between Los Angeles and Tokyo is 4,650 miles.) A type "F" tag of blue vinylite tubing secured with nylon line had been used (see Wilson, this issue, page 437). The fish was 76 cm. long when tagged. No valid information as to size or general condition was obtained at the time of recapture.

There were two earlier recoveries, both off Morro Bay, California, from the same group of 215. Both fish had traveled about 200 miles northwest from the same point of release as the individual recaptured off Japan and had been out 30 and 43 days, respectively.

The tag from Japan was returned to the Department of Fish and Game through the courtesy of Dr. Toshizo Nomura of the Kanagawa Prefecture Fisheries Experimental Station. Dr. Nomura forwarded the tag to Pacific Oceanic Fishery Investigations in Honolulu and that agency sent it on to California.—*David Ganssle and Harold B. Clemens, Marine Fisheries Branch, California Department of Fish and Game, July 10, 1953.*

THE USE OF MONOFILAMENT NYLON FOR ATTACHING PETERSEN DISK FISH TAGS[1]

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INTRODUCTION

The science of marking fish has been an important technique of fisheries workers for many years. Many methods and materials have been tried, but none have been entirely satisfactory. Petersen disks of cellulose nitrate are at present favored for tagging work in California, but constant experimentation with other types of tags and methods of attachment are being carried on. In general, the Petersen tag is applied with a stainless steel pin.

The Marine Fisheries Branch instituted a study of the kelp bass (*Paralabrax clathratus*) in 1950, which included a tagging program. During the years 1950 through 1952 results obtained from tags affixed with stainless steel and solid silver wire pins were discouraging. The wire materials were adequate, as far as resistance to corrosion or galvanic action were concerned, but the wire caught on kelp, rocks, or debris and bent badly. In many instances the tags were torn from the soft flesh of the back. In addition, water tunnel experiments and aquarium observations on yellowtail (*Seriola dorsalis*) showed a serious tendency of the stainless steel to bend sharply, presenting the broad surface of the tag to the flow of water. In the attempt to eliminate these serious faults, monofilament nylon was selected for trial during 1952.

In the early part of 1952, two marine research projects were activated, both of which were made possible through funds provided by the Federal Aid in Fish Restoration Act of 1950. These are the yellowtail study, project California F-1-R, and the surf fishing investigation, project California F-5-R.[3]

An important phase of each project was a study of tagging methods so that a suitable one could be adapted to the species of fish involved. For the yellowtail project many types of marking devices were tried. Monofilament nylon and stainless steel were chosen for attaching Petersen disks. Monofilament nylon has been used exclusively on the surf fishes.

The results of the tests conducted by these three investigations indicate that under certain conditions, monofilament nylon is superior to stainless steel or silver as a tag attachment material.

[1] Submitted for publication April, 1953.
[2] Federal Aid in Fish Restoration, Projects California F-5-R and F-1-R, respectively.
[3] The major surf fishes concerned are the spotfin croaker (*Roncador stearnsi*), yellowfin croaker (*Umbrina roncador*), corbina (*Menticirrhus undulatus*), and barred perch (*Amphistichus argenteus*).

AQUARIUM OBSERVATIONS

These tests were conducted at the Scripps Institution of Oceanography, University of California, La Jolla. We are indebted to Scripps for its cooperation, and to the aquarium staff for its interest and care of the tagged fish.

The first experiments were started March 7, 1952. Monofilament nylon was used to attach Petersen disks, at a point slightly anterior to and below the insertion of the first dorsal fin on three yellowtail. The appearance of the tags on the fish was not reassuring, as the knots in the nylon were rather clumsy and allowance for growth was excessive. Petersen disks were attached to additional yellowtail with stainless steel pins. Periodic observations showed that nylon attachments were unchanged in outward appearance, but stainless steel pins were uniformly twisted to a position at right angles to the flow of water (Figure 1). Yellowtail were frequently observed rubbing their sides along the bottom of the aquarium, which probably caused the twisted pins. On June 19, 1952, an aquarium accident terminated the experiment with the yellowtail.

FIGURE 1. Yellowtail tagged with Petersen disks attached with stainless steel wire. The tag is bent at a right angle to the flow of water. This may be caused by rubbing on the bottom, by contact with floating objects, or possibly by swimming speed in open water.

In the same experiment 11 kelp bass were tagged with nylon-attached disks. Four of these fish were tagged through the back at a point slightly forward of the junction of the spinous and soft dorsals. Four bass were tagged through the upper caudal lobe adjacent to the urostyle. The re-

TABLE 1

Aquarium Tagging Experiment With Spotfin and Yellowfin Croakers, Started May 28, 1952

All fish marked with both concave Petersen disks and opercular strap tags

Species	Spacing of tag	Appearance of nylon knot	Injury caused by tag	Other injury or disease	Disposition
Spotfin	Very loose	Bulky, loose	Slight depression posterior edges of tag	None	Alive April, 1953. Petersen present, opercular lost within three months.
Spotfin	Good	Tight	Slight depression at lower part of tag	None; large well healed 1/8-inch hole through flesh at nylon	Alive April, 1953. Petersen present, opercular lost within three months.
Spotfin	Very tight	Bulky	Very deep depression at lower lip of tag, but not through scales. No raw spot on injury	None	Alive April, 1953. Petersen present, opercular lost within three months.
Spotfin	Good	Bulky, loose	Slight depression at lower edge of tag	None	Alive April, 1953. Petersen present, opercular lost within three months.
Spotfin					Died of tail rot within one month.
Spotfin					Died of tail rot within one month.
Spotfin					Died of tail rot within one month.
Yellowfin	Tight	Bulky, loose	None	Pink, fleshy growth filling space between tag and fish. Raw spot under one tag	Alive April, 1953. Petersen present, opercular lost within three months.
Yellowfin					Died of tail rot within one month.
Yellowfin					Died of tail rot within one month.
Yellowfin					Released June, 1952
Yellowfin					Released June, 1952

maining three were marked with Norwegian hydrostatic tags, substituting a nylon bridle for the stainless steel bridle. Except for the hydrostatic attachments, the tags again appeared poorly spaced and awkwardly tied.

On July 13, 1952, all tags were intact, although tags placed through the backs and tails of the bass were obviously secured too tightly, and were causing marked localized irritation. In September, 1952, three back tags and one hydrostatic tag remained attached. At the present time (April, 1953), the three back tags are still in place. The experiment indicated that as a tagging material, nylon had tentatively measured up to the requirements of flexibility, nontoxicity and retained tensile strength under salt water conditions. The problem of knotting and spacing still required solution.

On May 28, 1952, 12 croakers (seven spotfin and five yellowfin), were tagged experimentally with concave Petersen disks attached with a doubled strand of nylon; in addition conventional strap tags of metal were attached to the opercle of five spotfin, and four yellowfin. The nylon attachments were firmly anchored to the croakers by running the strands through the supraoccipital crest of the head (Figure 8).

One week after tagging, three spotfin and two yellowfin croaker had died of tail rot, and two more yellowfin were returned to the sea in an attempt to remove the source of contamination. After 10 months of aquarium life, four spotfin and one yellowfin and their Petersen tags were in excellent condition. The opercular tags gradually cut their way out of the opercle and were lost. (See Table 1 for details.)

OBSERVATIONS IN THE SEA

Kelp Bass

Tag recoveries for silver and stainless steel exhibited a sharp decline throughout 1950, 1951 and 1952. For these two materials the recovery rate was very similar and the data have been combined (Table 2). Over 88 percent of the total metallic recoveries occurred within 60 days. For the nylon-attached tags only 68 percent of the total were returned within the same interval. The comparison between the recovery rates of nylon and silver is subject to error because the bass were not tagged with both

TABLE 2

Tag Recovery Rate of Tagged Bass by Type of Attachment

Tag attachment	Time out in days				Totals
	1-30	31-60	61-90	91-180	
Stainless steel and silver—1950-52	214	85	23	17	339
Nylon—1952	40	35	22	14	111
Totals	254	120	45	31	450

at the same time and place. The recovery rates throughout a 180-day interval, however, show a marked difference. A chi square test of these data (Table 2) gave a highly significant P value of less than 0.0001, indicating that a higher percentage of recoveries can be expected from nylon-attached tags over a greater period of time.

TABLE 3

Kelp Bass Tagging and Recovery Data, 1952

Material	Number tagged	Number recovered	Percentage recovered
Nylon	1,146	114	9.9
Silver	904	63	6.9

Of the 2,050 kelp bass marked in 1952, 1,146 were tagged with nylon and 904 with silver wire. From these fish, tagged under similar conditions, nylon returns were 9.9 percent and silver wire 6.9 percent. A chi square test applied to the data in Table 3 gave a probability (P) value of 0.02, thus indicating that tags attached with nylon will tend to give higher total recoveries.

Part of the bass tagging in 1952 took place in Avalon Bay, Santa Catalina Island. Several hundred bass were released very near to an anchored diving barge from which several full-suit dives were made every day throughout the summer months. The divers were interested in the conduct of the tagged fish, and noted that fish tagged with silver exhibited a marked tendency to rub violently against the rocks on the bottom. These people recovered several sets of tags, and all but one set had been secured with silver wire.

Yellowtail

At the end of March, 1953, a total of 501 yellowtail had been marked and released. Nearly all of these fish were double tagged, using Petersen disks as the basic tag plus one of several experimental types. The first 71 fish were marked with Petersen disks attached by type 302 stainless steel wire and the remaining 430 fish with disks attached by monofilament nylon.

Twenty-one nylon-tagged yellowtail and six with stainless steel attachments have been recaptured. No change of tag condition has been noted where nylon was used. The area around the tagging wound has been sound with little evidence of irritation. Two fish of the six stainless steel returns were seen and the area around the disks and the hole through which the pin was passed was torn and irritated. It was evident that within a short time the tags would have been lost. Figure 2 shows a nylon-attached tag on the right side of a yellowtail which was returned 172 days following release. The tag was lifted from the body to show the tissue beneath which was firm and healthy.

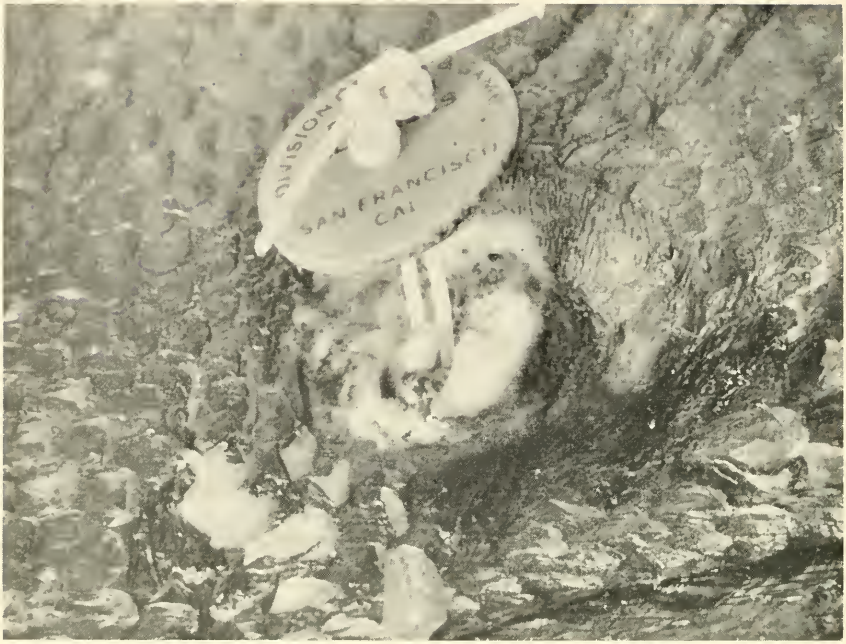

FIGURE 2. The tagging wound on a yellowtail recaptured 172 days after tagging. The area is clean with no evidence of infection. The tag is affixed with nylon.

Surf Fish

The tagging work carried on by the Surf Fishing project is complicated by the several species involved. Two slightly different tagging techniques have been used, both with nylon, which are explained in further detail under methods. Release and recovery data appear in Table 4. The condition of the tags and the fish have been satisfactory upon recovery.

TABLE 4

Tagging and Recovery of Surf Fishes From May, 1952, to March, 1953

Species	Number tagged	Number returned	Maximum time out, days
Spotfin croaker	260	23	53
Yellowfin croaker	65	6	80
Corbina	46	2	37
Barred perch	40	3	171
Other surfperches	109	1	154
Totals	520	35	

TECHNIQUE

Knots

Nylons, particularly monofilaments, are famous for slipping their knots. The knots described in the text have proven to be satisfactorily free of slippage. The variety of knots that have been used and accepted as satisfactory are arranged by name in Table 5.

The beginning knot is tied in the nylon before tagging takes place. The finishing knot is used to complete the tagging process.

TABLE 5

Knots Used for Tagging Work

Name of knot	Beginning knot	Finish knot	Reference
Blood knot	Yes	Yes	Figs. 3, 4, 6
Turban knot	Yes	No	Fig. 5
Double square knot	No	Yes	Text
Triple overhand w/square knot	No	Yes	Text

The blood knot is fairly difficult to tie, although actually quite simple in design. The finishing blood knot is identical with the beginning knot, but is tied in a different manner as indicated in Figure 6.

The turban is currently used only as a beginning knot, but because it can be easily positioned in the loop stage, it is possible that a way can be devised to utilize it for finishing. There has been no indication of failure of any of these knots either in the wild or in the aquarium.

Until the latter part of the 1952 tagging season, a double wrap square knot was used as the principal finishing knot for the kelp bass and yellowtail work. The usual square knot is tied with two single overhand wraps, one on top of the other. (A single overhand wrap is used before tying the bow of a shoelace.)

Surf fish were finished with two or three experimental knots but a triple overhand (with three loops instead of one) with a single square knot on top proved to be most satisfactory. It has been used in tagging 350 fish, from which there have been 22 tag returns.

Great care must be used in tightening the triple-overhand knot so that the tag does not compress the flesh, for this will diminish the essential spacing and can cause a cutting of the flesh by the nylon. The triple-overhand knot is drawn down only enough to remove the slack in the nylon between the tags, in such a manner that the flesh is not compressed. The square knot, which follows, is the locking knot that must be drawn tight.

A length of nylon about 30 inches long has been found to be preferable for tagging work. The 30-inch strand is first doubled, and one or the other of the two beginning knots is tied. Figures 3, 4, and 5 indicate the sequence of the tying processes. The wrapping sequence in Figure 3 has been abbreviated as two wraps are much easier to show than the three or four wraps that are used in the field.

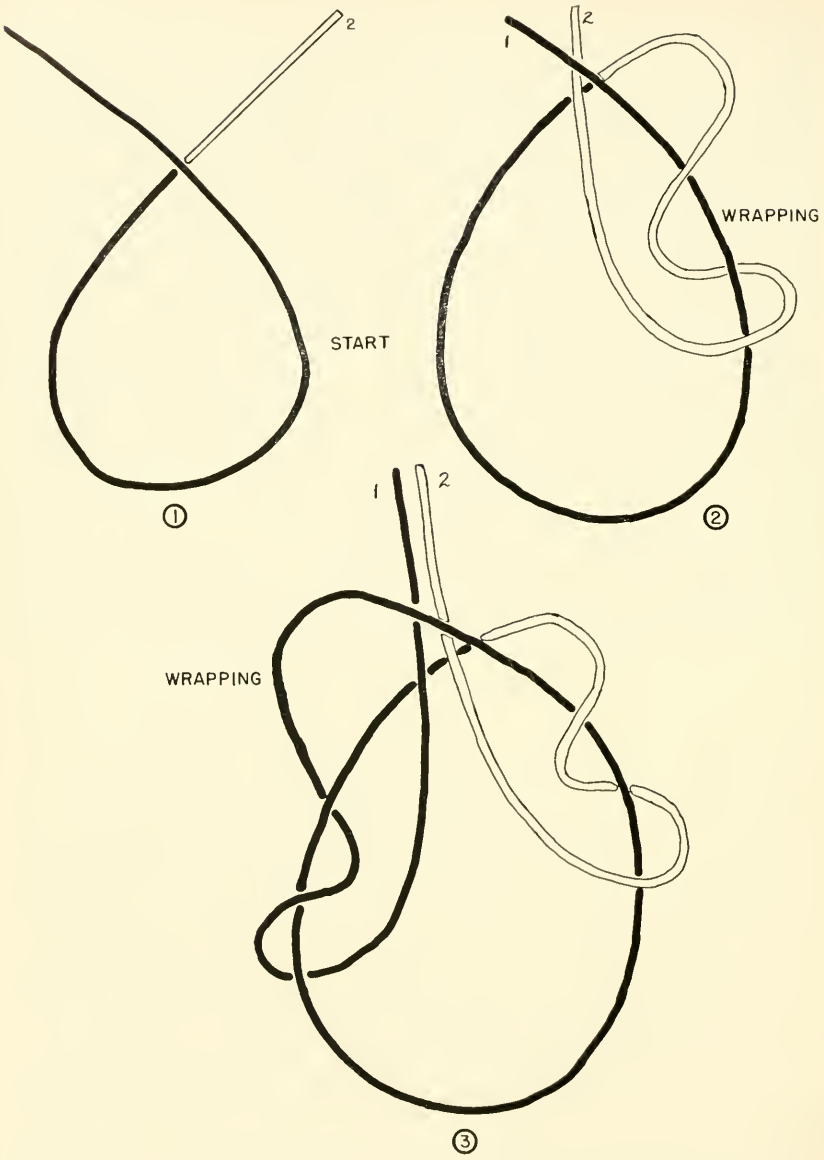

FIGURE 3. The sequence used in tying the blood knot when used as a beginning knot

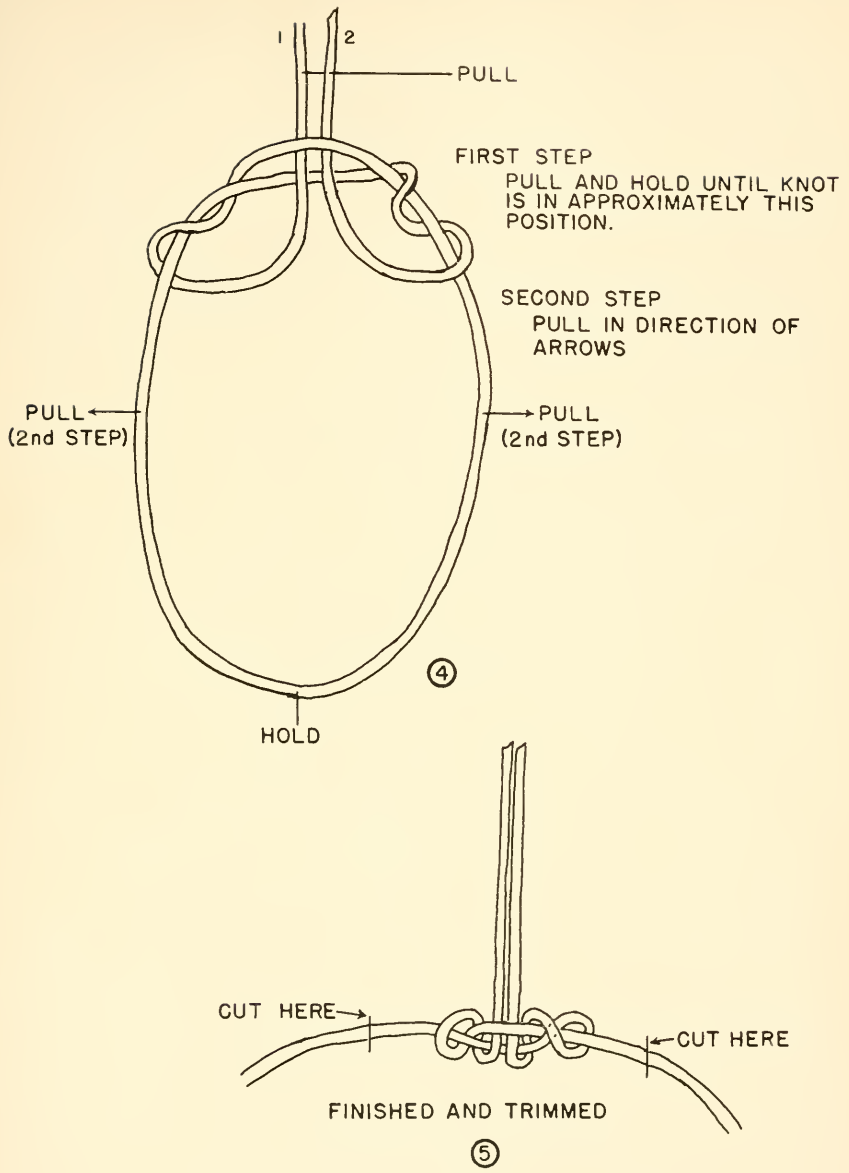

FIGURE 4. Completing the beginning blood knot

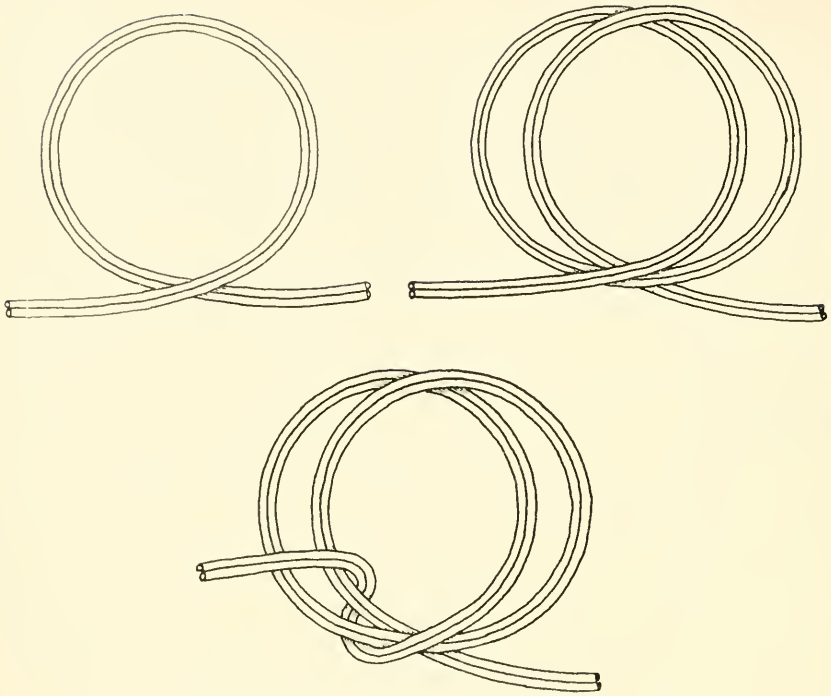

FIGURE 5. The sequence used in tying the turban knot

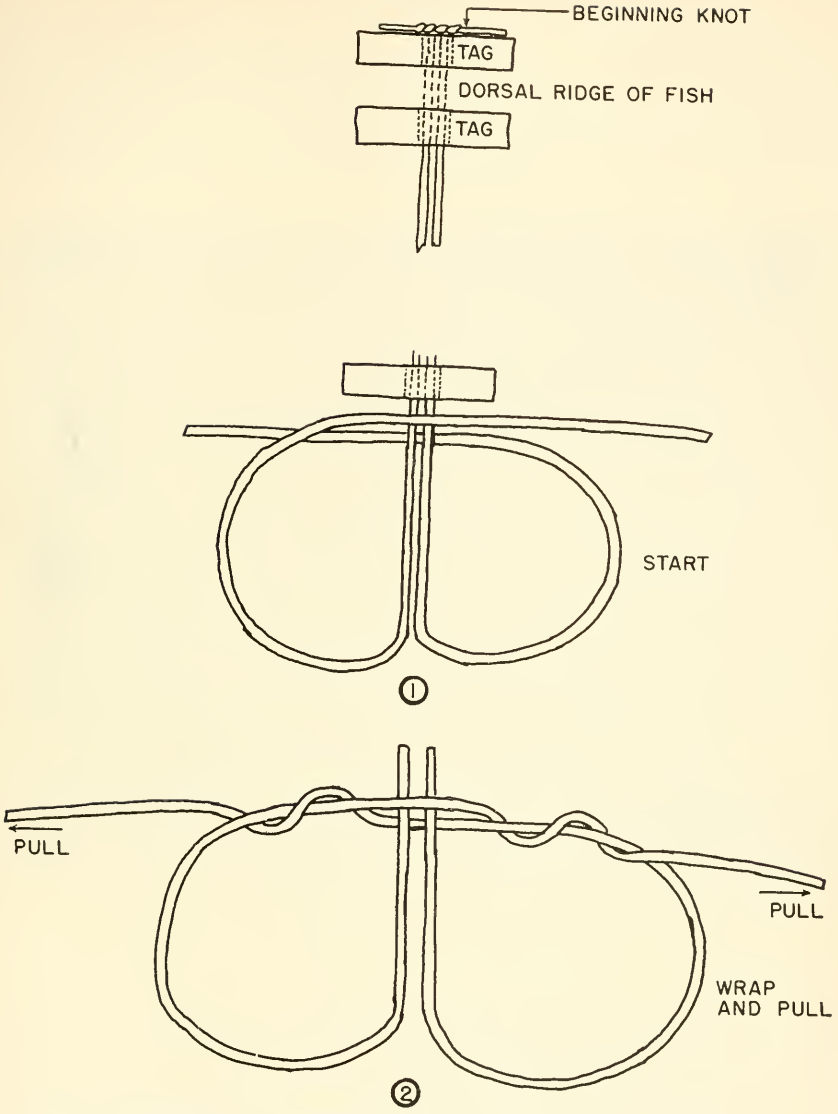

FIGURE 6. The sequence used in tying the finishing blood knot

Tagging Methods

For croakers and surfperch a tag placed on the posterior dorsal part of the head, with the nylon filaments passing through the high-crested supraoccipital bone, offered the advantage of an excellent anchorage and of being attached in a position of least possible muscular flexion. The tag so anchored seemingly provides less tissue irritation and less physical discomfort for the fish.

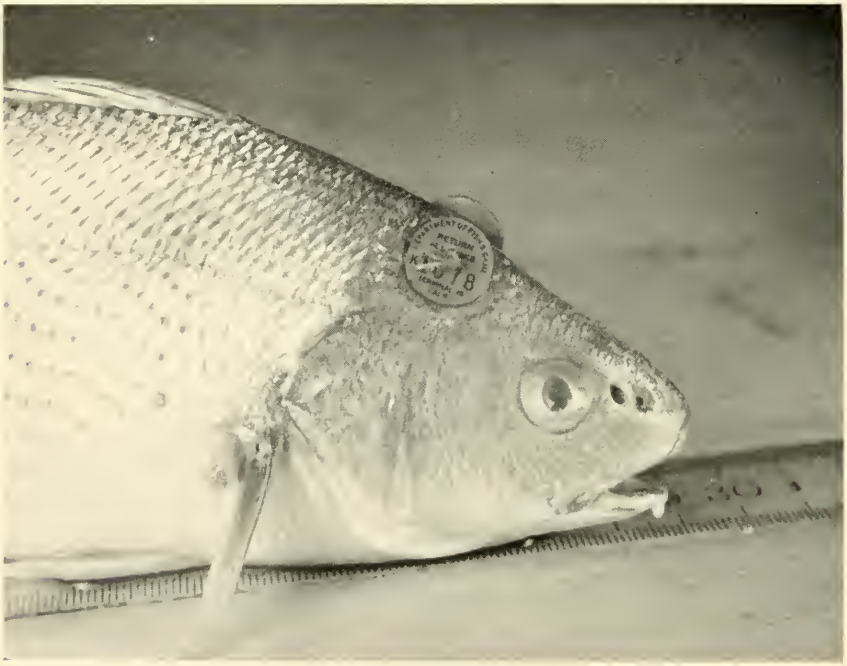

FIGURE 7. A Petersen disk secured with monofilament nylon to the supraoccipital bone of a yellowfin croaker

Since the flat Petersen disk might have a tendency to cut into the fish at the edges of the tag, thereby encouraging abnormal tissue growth, fungi, and bacterial infections, a concave tag was used hoping to eliminate this source of trouble. Inasmuch as surf fish are comparatively slow swimming, additional water resistance due to the concavity of this tag should not adversely affect the point of attachment.

The corbina, yellowtail, and kelp bass are all tagged below and slightly posterior to the insertion of the first dorsal fin. These species lack the high supraoccipital crest. Flat Petersen disks have been used on the yellowtail and kelp bass and concave disks on the corbina.

In tagging the knotted nylon strands are trimmed, a numbered Petersen disk is threaded on, and the free ends inserted part way into a hypodermic needle. The needle is then pushed completely through the fish, leaving the free ends protruding on the side opposite the numbered disk. A second Petersen disk is then threaded over the free ends of the nylon, and a finish knot applied.

It is desirable to allow a small amount of space between the tag and the body of the fish. Space is not only for growth, but also for taking care of the shrinkage that seems to occur with the nylon. Various plastic spacing devices have been used. Figure 9 shows the tool used on surf fish. This spacer was made from two thicknesses of 0.080-inch sheet lucite and provides a spacing of 0.16 inch. Two spacers, each 0.045 of an inch thick, were used on yellowtail, one on each side of the fish.

FIGURE 8. A Petersen disk in position on the supraoccipital bone of a spotfin croaker

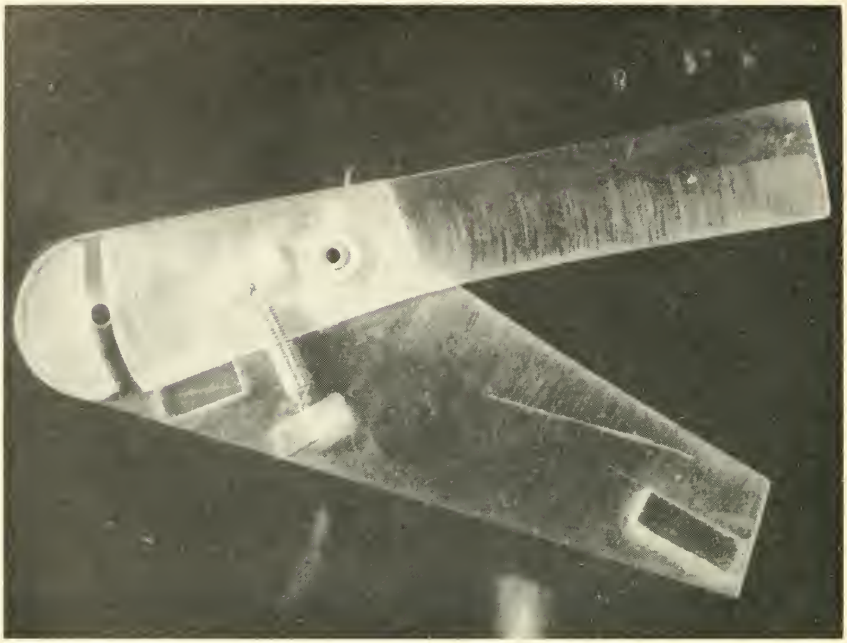

FIGURE 9. Plastic spacing device. This tool closes automatically when pressure is released from handles.

Considerable difficulty is experienced, particularly with the spotfin, in forcing a tagging needle through the supraoccipital bone without a suitable tool. Such a tagging needle tool has been designed and found to be very satisfactory for this purpose. It accelerates the work and prevents tissue injury due to erratic needle movement (Figures 10 and 11).

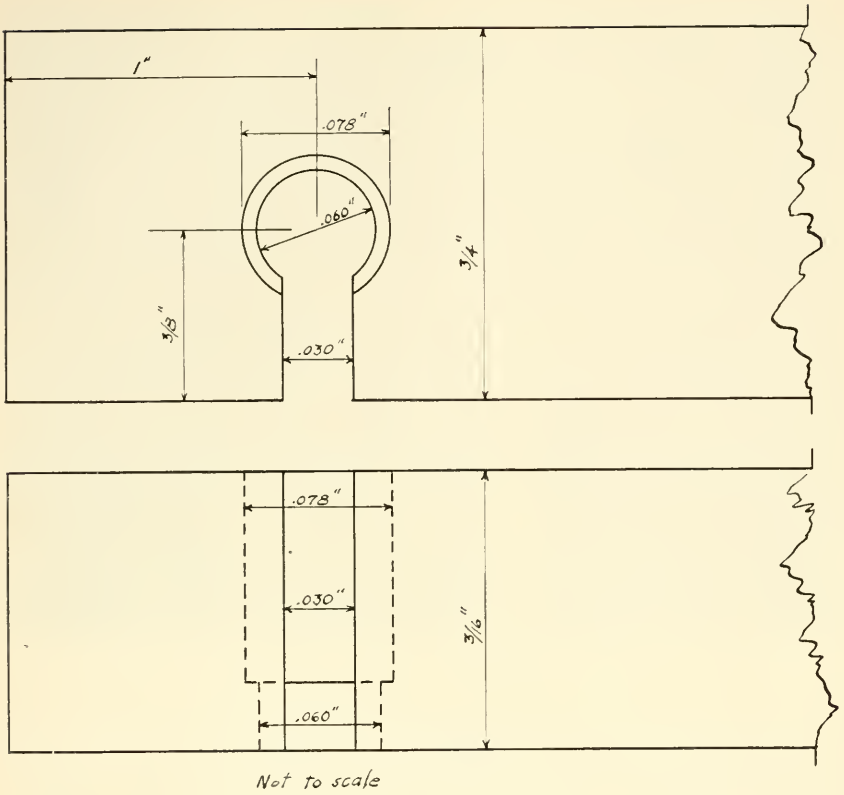

FIGURE 10. Diagram and specifications for the tagging needle tool. The material is stainless steel, adapted for use with a number 15, 3½-inch hypodermic needle. Tool is five inches long.

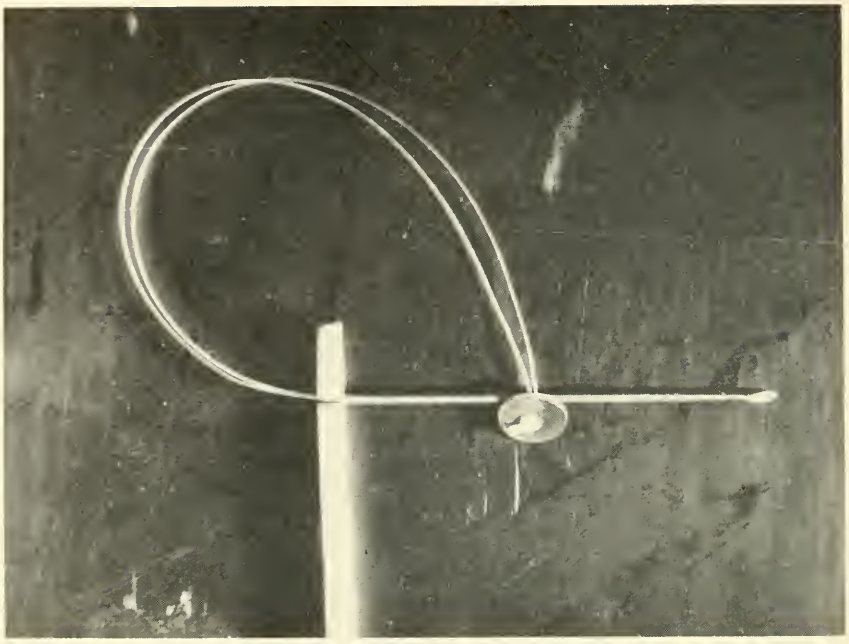

FIGURE 11. The needle tool, with needle and tag in place ready for tagging

TEST OF MONOFILAMENT NYLON

The material used for the experiments was rated at 15 pounds breaking strength. Tensile strength tests on *double* strands of new nylon material, knotted as it would be for tagging purposes, developed a breaking stress at less than 30 pounds. The tests were expected to indicate which of two commonly used knots caused the greatest loss in material tensile strength, and whether or not material recovered from returned fish had depreciated in quality. The double square knot and the blood knot compared quite closely in the tensile strength tests. The blood knot appears to be slightly superior, although breaking figures for both knots averaged approximately 21 pounds. Two tests on nylon recovered from tagged fish gave slightly different results. Nylon from a yellowtail that had been held in an aquarium for six weeks parted at a strain of 20 pounds. This was a material failure. The second test produced a failure at the blood knot, but this was at a 26-pound strain. The material for the second test was taken from a yellowtail that had been at liberty for 172 days following tagging. In both cases the line was examined under a microscope and found to be slightly scratched, but other damage or weakness could not be discovered.

DISCUSSION

Monofilament nylon, properly handled in an appropriate situation, may have real value for the fisheries worker involved in a tagging program. Nylon is available in a variety of forms, tensile strengths, diameters, and degrees of flexibility. Changes are constantly taking place within

the plastic industry that may offer superior materials within a relatively short time.

As yet there is no evidence of corrosion, although there has not been sufficient passage of time to say that it does not occur. The body fluids of the fish tagged have had little if any effect to date. There has been an alteration in the flexibility of some nylon materials. This might be classified as deterioration.

There has been no indication of toxicity to the species of fish tested.

The application of tags attached with nylon is relatively slow in comparison with stainless steel or other metals. Not only do knots slow the tagging process, but also proper spacing must be achieved before the fish are released. The use of removable spacing devices causes a time loss.

A strand of nylon of sufficient length to be used for tag attachment now costs about 1½ cents. A minute, more or less, is required to cut the strand from the coil, tie the beginning knot and trim the excess material away.

The advisability of using nylon for a long term project cannot be stated as there has been insufficient time to determine the effect of extended exposure to sea water.

CONCLUSIONS

The selection of the nylon material for tagging purposes will vary with individuals and with the habits and habitat of the fish involved. A comparison of the requirements of a spotfin croaker with those of the kelp bass offer a good example. A spotfin croaker provides a solid anchorage in the supraoccipital bone of the head. The nylon used here should be sturdy enough to resist possible cutting action by the bone edges. This region of the body would not produce the over-all increase in size through growth that could be expected in the central portion of the body. Spacing, then, is not the problem that would be present in the center of the back. A silver or stainless steel attachment would probably be less dependable, as the tagging wound is rather near the dorsal ridge of the body and a rigid material would tear out, through bone and all. A metallic attachment might prove to be as efficient as the nylon, but the writers do not think so at present.

The habitat of a spotfin croaker is in open areas near sandy beaches. The chances that a spotfin would encounter semisolid resistance to the tags, such as marine growths, are rather slim. If this should occur, a flexible nylon attachment would probably suffer less stress than would wire.

Kelp bass do not offer a solid point of attachment, must be tagged in the center of the body, are frequenters of kelp beds and rock outcroppings, and are probably consistently more active than spotfin. Silver and stainless steel attachments have been shown to be less efficient than nylon, but the type of nylon that would be most effective is another problem. Experience would indicate that under the above circumstances a moderately flexible nylon of approximately 20 pounds test would be best. This material is doubled in use, so it would have a potential breaking stress of 40 pounds. A lighter material may be just as efficient, but this

will depend on the brand name and probably on the lot. Too much flexibility may produce self cutting, particularly in the knots. Small diameter monofilament is also subject to self cutting.

The use of nylon on yellowtail, or any such fish that attains such large proportions and is extremely active, entails quite another problem. Yellowtail probably grow quite rapidly and would exert considerable stress as they are tagged in the center of the body. They are also fond of rocky shores and beds of kelp. A properly spaced tag should stay quite well until either growth of the fish or contact with kelp presented an obstacle. Growth would probably force the tag up to the dorsal margin of the body and eliminate it in that manner. It is doubtful that the nylon would part under growth stress. If kelp or similar type of resistance should be met, the power and speed of the fish would cause the loss of the tag through breakage of the tag or the nylon, or by its tearing out of the flesh.

The results of nylon in use as a method of tag attachment indicate that, under some circumstances at least, nylon will be more efficient than either stainless steel or silver wire. Furthermore, as the technique of application is improved there should be even more favorable return from the tagging programs.

CREEL CENSUS AT MILLERTON LAKE, CALIFORNIA, 1945-1952[1]

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Inland Fisheries Branch, California Department of Fish and Game

INTRODUCTION

One of the objectives of the Department of Fish and Game's warm-water program is to discover why the large fluctuating reservoirs in the foothills of the Sierra Nevada produce so few game fish and to find means of improving the quality of fishing in them. To help achieve this goal, Millerton Lake (Figure 1), a key feature of the U. S. Bureau of Reclamation's Central Valley Project, was selected some years ago as a representative example for intensive study. Many of the conclusions resulting from the Millerton Lake studies may also be expected to apply

FIGURE 1. Aerial view of Millerton Lake, California. *Photograph by Elden H. Vestol, October 10, 1951.*

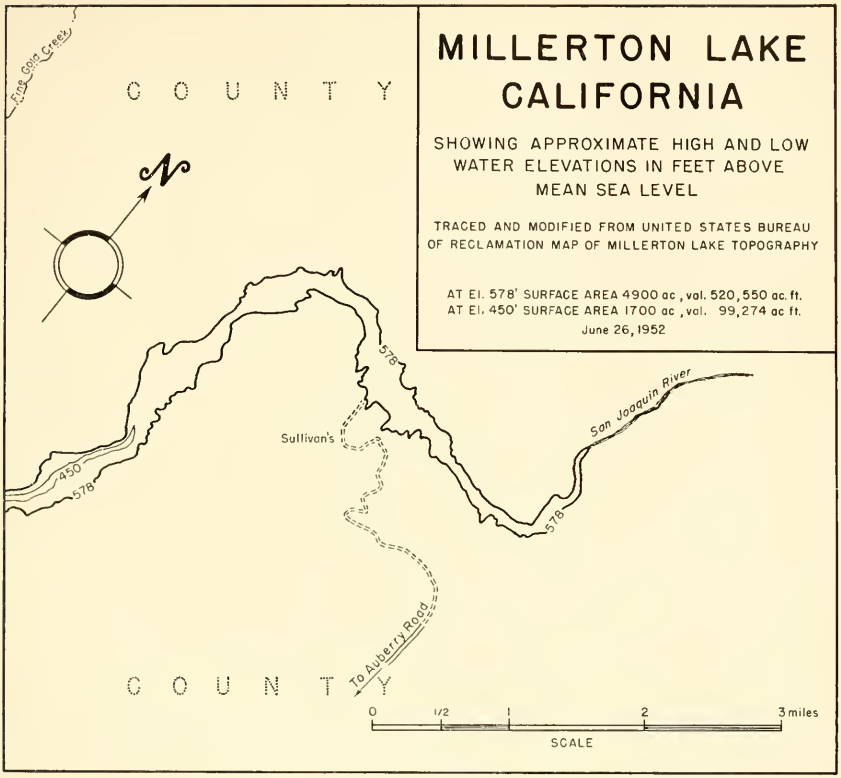
[1] Submitted for publication June, 1953.
[2] Now National Science Foundation Fellow at the University of California, Berkeley.

FIGURE 2. Map of Millerton Lake. Elevations are in feet above sea level.

to the other waters, and any means found to improve angling at Millerton Lake should also apply to these other lakes and thereby materially increase the recreational resources of California.

Located in the foothills of the Sierra Nevada approximately 20 miles east of Fresno, Millerton Lake forms an important recreational resource for residents of the arid southern portion of the San Joaquin Valley of California. Dill (1946) described the lake and its basin in some detail and it will suffice here to say that it is a canyon type reservoir formed when complete control of the San Joaquin River was effected by Friant Dam in February 1944. It is about 16 miles long and varies from 1,700 to 4,800 surface acres in area. Fluctuation of the surface level often exceeds 100 feet a year, with late summer being the period of lowest water. The average elevation is about 500 feet above sea level. The presence of a single large, shallow bay, the South Bay in Figure 2, is an advantage that most foothill reservoirs do not enjoy.

A large share of the work at Millerton Lake has centered around a long range creel census. This census, covering the period 1945-1952, is the longest and most complete ever made on a warmwater lake in Central or Northern California.



Primary purposes of the census were to provide as full a description of the fishery as possible, to follow its trends throughout the years, and to establish standards of comparison by which fisheries of similar California waters could be evaluated. Such standards (fishing quality and intensity, annual yield, etc.) are fairly well known for coldwater fisheries in California, but heretofore it has been necessary to use figures from other states when comparing warmwater fisheries.

Dill (1946) reported upon the first year of angling and included a careful description of the lake and many of its problems. The current report presents the results of the following seven years of census and provides, with the above paper, a detailed record of the first eight years of fishing. This information will be valuable for comparison in the future, when possible changes resulting from the introduction of new species of fishes and other fish management activities will have had an opportunity to have an effect.

The fishery is primarily for largemouth black bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*), with green sunfish (*L. cyanellus*) entering the catch in small numbers. A few smallmouth black bass (*Micropterus dolomieu*) and rainbow trout (*Salmo gairdneri*)

are taken each year, and brown bullhead (*Ameiurus nebulosus*) and black crappie (*Pomoxis nigro-maculatus*) are seen on rare occasions.

The great fluctuation of Millerton Lake is not conducive to high productivity. Nevertheless, census records (Dill, 1946) and prevalent opinions agree that fishing was good during 1945 and 1946. The Average catch declined in 1947 and reached an extreme low in 1948, from which it has now recovered to a level about half of that for the peak years. At present, experienced anglers find fishing for both of the major species generally satisfactory, but less expert fishermen usually find it poor. Because large numbers of inexperienced fishermen visit the lake, Millerton has a poorer reputation than it probably deserves.

METHODS

Millerton Lake has been accessible throughout most of the eight-year census period at three points. Of these, Gate One has been the most heavily used and, therefore, received most of the census effort. Whenever possible, checks were also made at Gate Two, which is used primarily by shore fishermen visiting the South Bay. The third entrance, a dirt road leading to the upper end of the lake through the Sullivan Ranch, has been used only briefly in the spring and early summer each year, when the lake is high and the route passable. It has received only limited attention in the census. In addition, the road to Winchell Cove was checked occasionally during the part of 1952 when it was opened and used.

At Gates One and Two cars were stopped as they left the lake and information was obtained on the number of anglers, the number and weight of fish taken, and the fishing methods used. Each species was weighed in aggregate for the entire party. Checks at Sullivan's and Winchell Cove consisted only of a count of cars.

The long range study of Millerton Lake fishing may be divided into three periods, according to the intensity of the census schedule, as follows:

(1) The 1945 census consisted of daily counts of anglers and fish caught during the open season made largely by Bureau of Reclamation Guards and National Park Service Rangers. Dill (1946) estimates that 90 percent of the fishing effort was recorded that year.

(2) A three-year period of occasional censuses by the Department of Fish and Game followed. Creel counts were taken on the following dates:

1946: May 29 (opening day), June 2 (Sunday), July 4.
1947: May 29 (opening day).
1948: May 1 (opening day), May 2 (Sunday), May 29 (Saturday), July 3 (Saturday).

(3) During the four-year period which followed (1949-1952) the scope of the program was greatly intensified. Because counts were made on a schedule of about two per week (one weekday and one week-end day, rotated or alternated to avoid bias) throughout this time, this period is designated the period of semiweekly censuses. Census effort was actually reduced to four or six days per month after July 1951, but the plan of operation remained the same.

Estimates of the total number of anglers using Millerton Lake in this four-year period are based on the assumption that total angling

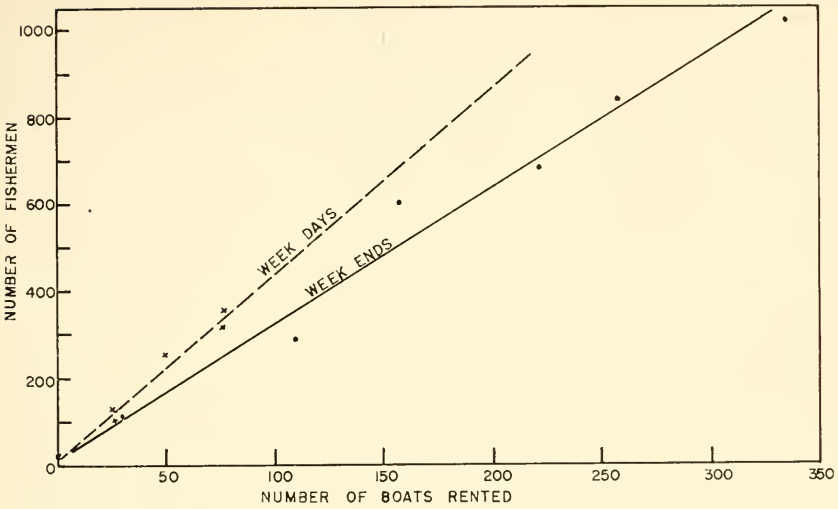


FIGURE 3. Relation of the number of boats rented at Millerton Lake to the total number of fishermen on the lake. Week-end points (dots) and weekday points (crosses) aggregate themselves along different regression lines (drawn in by eye).

effort was proportional to the number of boats rented (see Figure 3, in which a close correlation is shown). In monthly units, proportions were struck between numbers of censused anglers and rentals on censused days. Monthly estimates were then computed from known rentals, and total annual estimates followed, by summation. This system has been extremely convenient, for boat rental records have been kept faithfully by the single boat livery except during part of 1951. During this period it was necessary to derive the estimates directly from the semiweekly and weekly censuses on the assumption that these counts were representative of the uncensused days.

Annual estimates of total catch were obtained by summation of weekly catch estimates. Weekly estimates were derived by applying catch data for censused days to the estimated weekly fishing effort.

Census operations are summarized in Table 1.

TABLE 1

Census Operations at Millerton Lake, 1945-1952

Angling season	1945	1946	1947	1948	1949	1950	1951	1952
	May 29-Oct. 31	May 29-Oct. 31	May 29-Oct. 31	May 1-Dec. 31	Entire year	Entire year	Entire year	Entire year
Number of census days								
Gate One	156	3	1	4	60	93	76	59
Gate Two	Closed	3	0	4	[1]12	5	2	10
Sullivan's					3	3	0	6
Cars checked	15,567	626	260	1,069	2,609	4,173	4,226	2,809
Fishermen per car		2.4	2.2	2.4	2.1	2.2	2.3	2.2

[1] Closed or unused most of the remaining days.

CENSUS RESULTS

Fishing Effort

Estimates of the total number of anglers using Millerton Lake have been made for all of the years of study except those during the period of occasional censuses and are as follows:

1945	27,396
1949 (April through December only)	24,443
1950	35,851
1951	45,420
1952	36,700

Roughly two-thirds of the anglers at Millerton fish from boats, most of the other third remaining on shore in the South Bay.

Using 3,500 acres as the average surface area for Millerton, fishing pressure in 1952 amounted to 10.5 fisherman days per acre. This rather low figure could be expected to rise considerably if angling were to improve. Because fishing and fish production are both limited in a lake such as this to a narrow band close to the shore (the littoral zone) totaling about 400 acres, fishing pressure actually amounts to about 92 angler days per acre. Area relationships of effort and catch are shown in Table 2.

Interviews in 1950 and 1951 revealed that nearly half of all anglers fish specifically for bluegill (all worm fishermen were assumed to be seeking bluegill). Fishermen seeking bass and those seeking both species (combination fishermen) each comprise about one-fourth of the total. Presumably these proportions will vary rather widely in accordance with the success being enjoyed for either species in any particular year.

Breakdowns of angler effort for each of the years in which data were taken are summarized in Table 3.

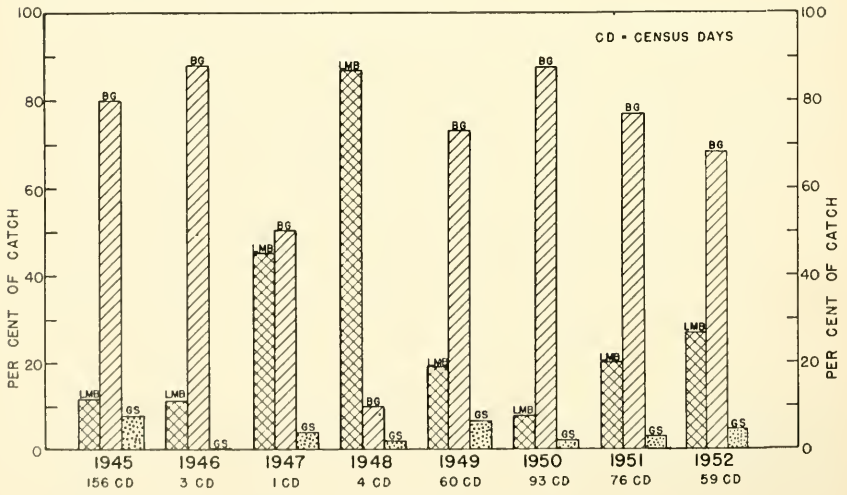


FIGURE 4. Composition of the catch at Millerton Lake, as indicated by creel census records, 1945 through 1952.

TABLE 2

Angler Effort and Catch at Millerton Lake

	1945		1949		1950		1951		1952	
	Entire lake	Littoral zone[1]	Entire lake	Littoral zone	Entire lake	Littoral zone	Entire lake	Littoral zone	Entire lake	Littoral zone
Maximum surface area in acres	4,486	411	4,486	411	4,433	410	4,540	414	4,486	411
Fisherman days per acre	6.4	70.4	5.4	59.5	8.1	87.4	10.0	109.7	8.2	89.3
Number of fish caught per acre	36.2	395.0	7.9	86.5	26.3	284.0	29.2	320.0	15.5	169.5
Pounds of fish caught per acre	No record	No record	2.6	28.8	6.7	72.3	7.5	82.3	5.1	55.4

[1] Littoral zone calculated as water which is less than 16 feet deep.

TABLE 3

Classification of Angler Effort From Interviews at Millerton Lake

	1945	1946	1947	1948	1949	1950	1951	1952
Fishermen interviewed	27,396	1,476	588	2,556	5,425	9,054	8,864	6,071
Shore fishermen, percent		39	29	32	38	36	34	37
Boat fishermen, percent		61	71	68	62	64	66	63
Bass fishermen, percent						26	38	29
Sunfish fishermen, percent						46	40	49
Combination fishermen, percent						27	22	22

TABLE 4

Composition of the Observed Catch at Millerton Lake

	1945[1]		1946		1947		1948		1949		1950		1951		1952	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Largemouth black bass	19,638	12.1	1,215	11.5	1,035	45.4	947	86.8	1,624	19.2	3,045	10.3	4,813	20.2	3,032	27.3
Smallmouth black bass	148	0.1	3		0		1	0.1	6	0.1	3		3		3	
Bluegill	129,349	79.8	[2]9,333	88.0	1,153	50.6	108	9.9	6,211	73.5	25,883	87.8	18,284	76.8	7,555	68.1
Green sunfish	12,935	8.0	30	0.3	87	3.8	22	2.0	546	6.5	535	1.8	714	3.0	497	4.5
Hybrid sunfish[3]	No record		1		7	0.3	1	0.1	52	0.6	14		Counted as bluegill		Counted as bluegill	
Rainbow trout	96	0.1	17	0.2	0		11	1.0	9	0.1	9		4		4	
Brown bullhead	0		0		0		0		2		1		1		0	
Total observed game fish catch	162,166	100.1	10,599	100.0	2,282	100.1	1,090	99.9	8,450	100.0	29,490	100.0	23,819	100.0	11,091	99.9
Rough fish[4]	No record		50		10		34		22		82		71		61	

[1] Records show 19,786 "bass," 142,284 "sunfish." Catch composition was estimated by Dill (1946).
[2] Includes 387 unsegregated sunfish.
[3] A bluegill-green sunfish cross.
[4] Predominant species were Sacramento squawfish (*Ptychocheilus grandis*) and carp (*Cyprinus carpio*), with occasional Sacramento hitch (*Lavinia exilicauda*), greaser blackfish (*Orthodon microlepidotus*), and riffle sculpin (*Cottus gulosus*). Actually few of the rough fish taken are brought out, so the numbers in the table are not truly representative of the catch.

Catch Composition

Species composition of the catch at Millerton Lake is usually fairly consistent, bluegill comprising approximately 80 percent and bass making up nearly all of the remainder, as shown in Table 4 and Figure 4. Notable exceptions to this generalization are indicated for the years 1947 and 1948. However, the bluegill slump in these years may have been more apparent than real. It is emphasized that only one and four censuses, respectively, were held during these two years and that these censuses were centered fairly early in the season, when bass fishing is generally above average and bluegill fishing below average.

Green sunfish have never figured significantly in the catch, in either numbers or size, in spite of the fact that 90.6 percent of the fish originally planted were of this species. Dill (1946) reports that 317,750 green sunfish, 32,440 largemouth black bass, and only 375 bluegill were placed in the lake in 1942 and 1943.

Bluegill are indisputably superior to green sunfish in utilizing this type of reservoir environment, but may be subject to violent population fluctuations.

The number of green sunfish taken each year is fairly constant, and variations in the percentage of the total catch formed by them are actually due to fluctuations in bluegill abundance. The highest percentage (8 percent) occurred during the first year of fishing. The only time that this figure was again approached was in 1948, when bluegill appear to have been extremely scarce. Green sunfish larger than one-fourth pound are almost never seen at Millerton Lake, and as a consequence these fish are not considered very desirable.

Estimates of Total Catch

Estimates of the total catch of the major game species at Millerton Lake have been made for 1945 (by actual count, thought to have been approximately 90 percent complete by Dill, 1946) and for the period of semiweekly censuses, 1949 through 1952. They are shown in Table 5. These figures indicate a relatively high catch of bass and bluegill for the five-month season in 1945, a much lower catch for the late slump year of 1949 (probably the beginning of recovery from the slump; census covered April through December), a notable increase as fishing improved again in 1950 to 1951, and finally the beginning of a slight decline in 1952.

TABLE 5

Estimated Total Catch at Millerton Lake

	1945	1949	1950	1951	1952
Largemouth black bass	19,638	7,643	12,292	25,650	21,000
Smallmouth black bass	148	12	9	3+[1]	3+[1]
Bluegill	129,349	25,650	101,917	103,000	45,500
Green sunfish	12,935	2,043	2,190	3,729	3,200
Hybrid sunfish	–	185	86	Counted as bluegill	Counted as bluegill
Trout	96	41	26	4+[1]	4+[1]
Total	162,166	35,574	116,520	132,386+	69,700

[1] Numbers of smallmouth black bass and trout too small in 1951 and 1952 for estimation of totals. At least three and four, respectively, are known to have been taken.

Fishing Quality

In a general way, present fishing quality at Millerton Lake can best be described as usually fair but occasionally good for those who know the lake and its peculiarities and consistently poor for inexperienced fishermen.

Three different measures of fishing quality have been derived from the Millerton Lake data. They are (1) catch per unit of effort, (2) catch per unit of area, and (3) percentage of fishermen catching nothing (zero catches).

The unit of effort which was found to be most useful in this work is the fisherman day. The collection of data in all cases at the end of the angler's day makes this a simple unit to use and provides the same sort of expression of success that is used by the anglers themselves. Average fishing days for the various classes of fishermen in 1952 were:

All fishermen	4.6 hours
Shore fishermen	3.0 hours
Boat fishermen	5.5 hours
Bass fishermen	4.4 hours
Sunfish fishermen	4.0 hours
Bass and sunfish fishermen (combination fishermen)	5.1 hours

The record of catch per fisherman day taken from censuses since the opening of fishing in 1945, shown in Table 6 and Figure 5, is typical of the sequence of events in new warmwater impoundments. From

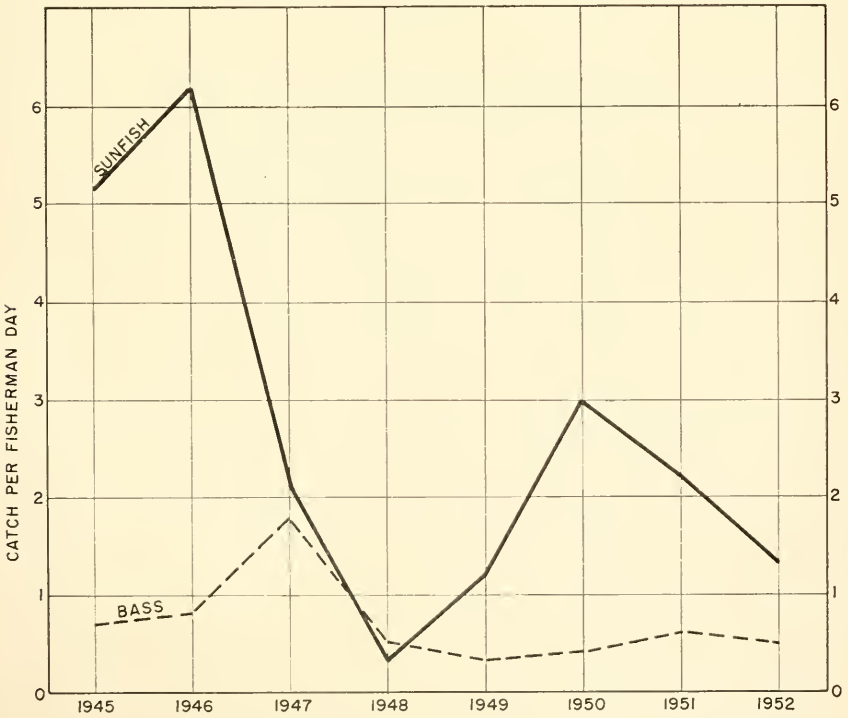


FIGURE 5. Trends in fishing quality at Millerton Lake, measured in catch per fisherman day by all anglers, 1945 through 1952

an initial peak of around five and six fish per angler day in 1945 and 1946, respectively, sunfish fishing [1] dropped to an indicated 0.33 per angler day in 1948. Recovery began in 1949 and a second peak at 2.92 bluegill per fisherman day was reached in 1950. Following this the catch again declined through 1951 and 1952 to 1.33 bluegill per fisherman day in the latter year.

Bass fishing has followed the same trend with a delay of a year or less. The years 1945 and 1946 are generally acknowledged to have been the peak years, with 1947 providing a good opening (hence the extreme peak for the 1947 census, which was taken on May 29 only) followed by a notable midseason drop. According to our census figures, which are admittedly scant for 1948, 1949 was the poorest year for bass fishing, whereas general notes, newspaper clippings, and angler opinions point

[1] Essentially bluegill, since green sunfish contribute only a small part of the catch and exhibit no significant changes.

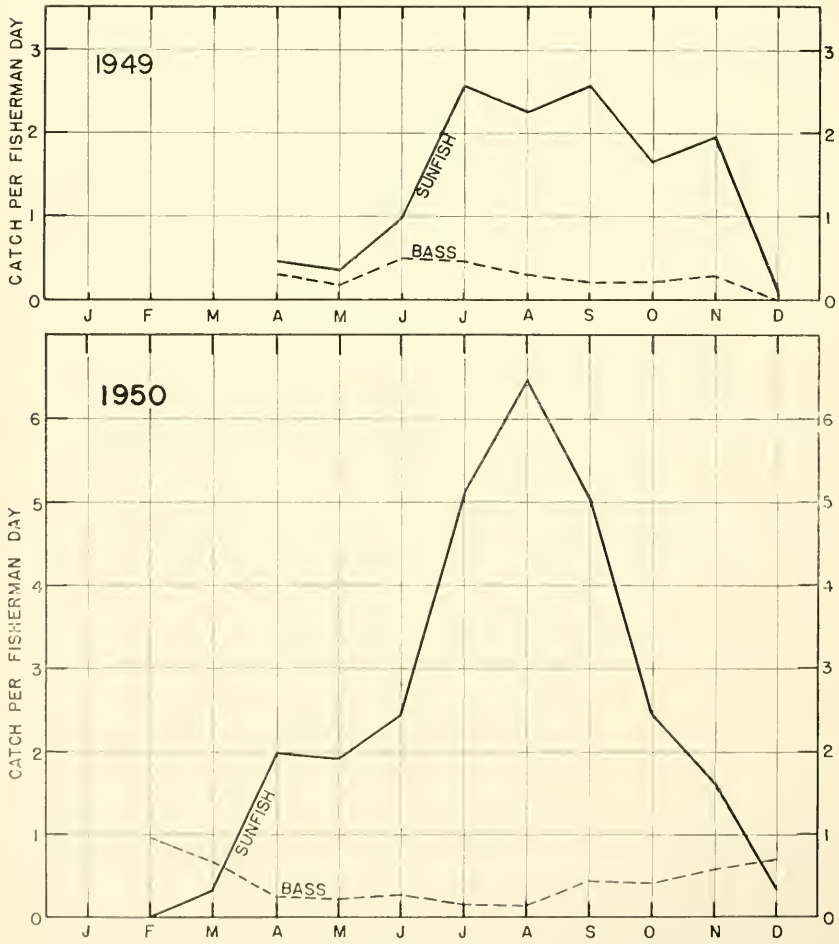


FIGURE 6. Fishing quality at Millerton Lake, measured in catch per fisherman day by all anglers for each month of 1949 and 1950

more toward 1948 as the worst year. Moderate recovery followed, with changes in bass fishing quality exhibiting a definite one-year lag behind the bluegill.

Monthly figures for fishing quality within the individual years (Figures 6-9) show a regular spring peak for bass coincident with the initiation of bass activity at that time, a midsummer lull, and in some years a notable fall peak as well. This fall peak failed to appear in 1952. By middle or late November the fall fishing slacks off and the winter period of inactivity starts for all but the largest fish. The few bass taken in December, January, and February are nearly always large.

The tendency for the early season bass peak to be divided into two parts may be correlated with periods of activity before and after the bass spawning season, which usually comes in May.

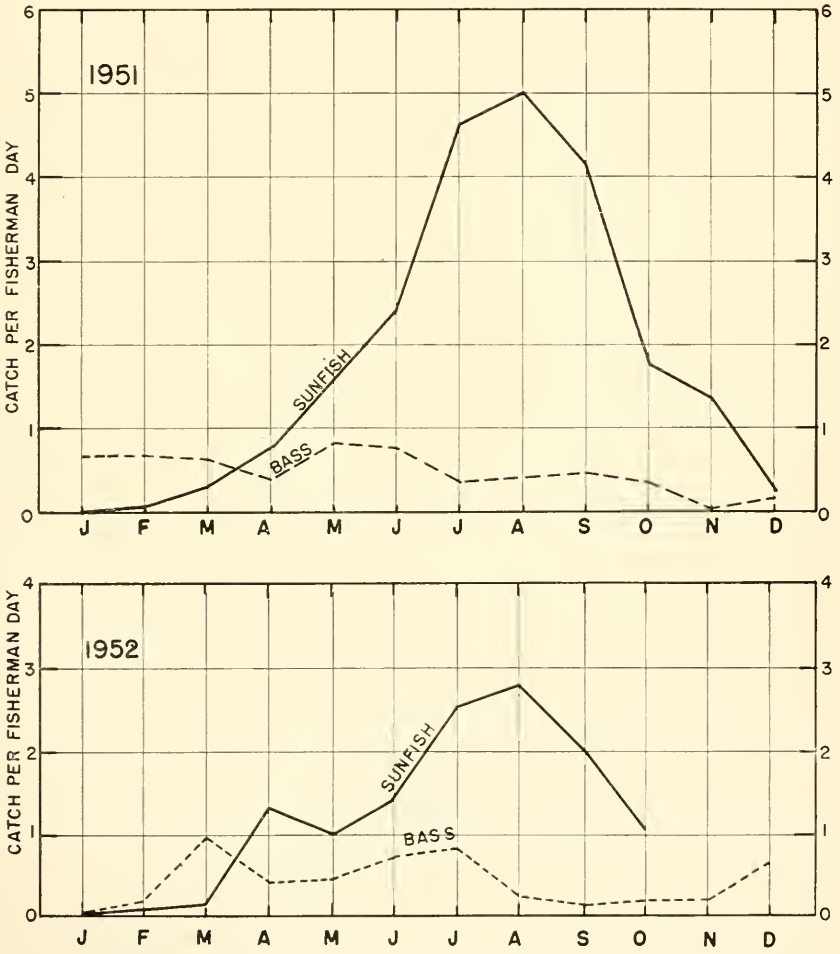


FIGURE 7. Fishing quality at Millertan Lake, measured in catch per fisherman day by all anglers for each month of 1951 and 1952

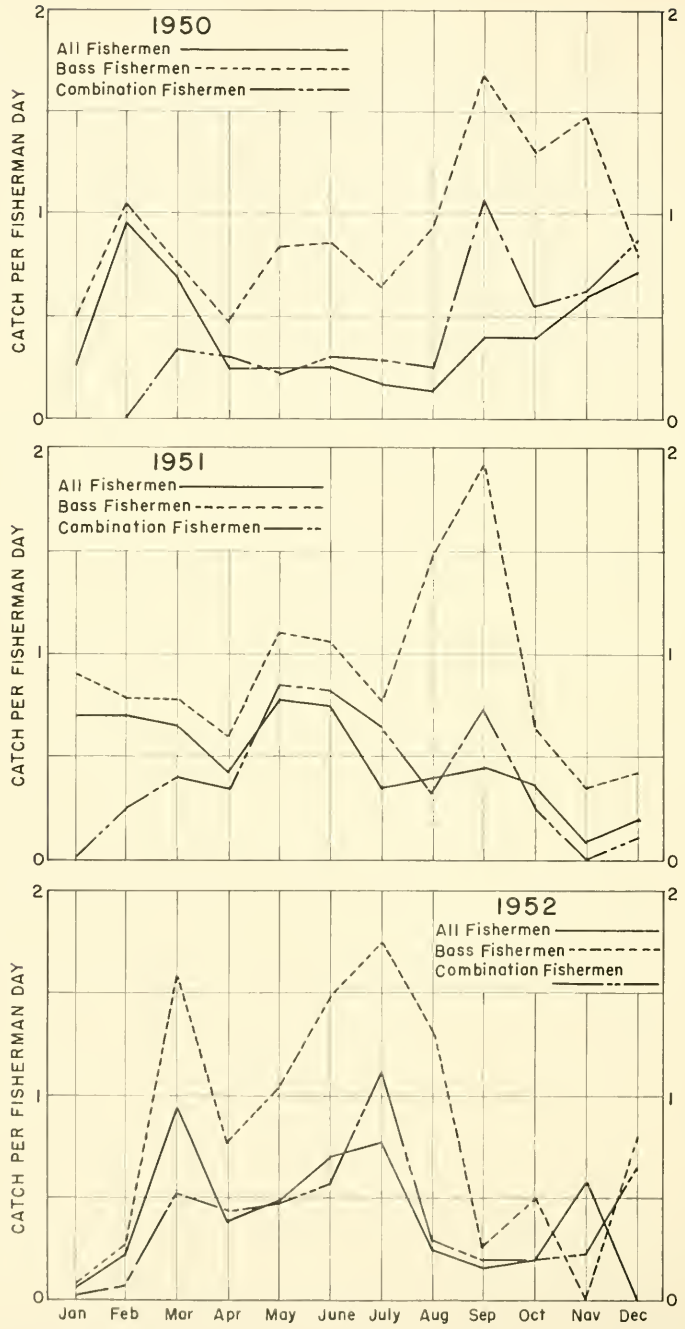


FIGURE 8. Quality of bass fishing at Millerton Lake, measured in catch of bass per fisherman day for each month of 1950, 1951, and 1952; data segregated as to species sought

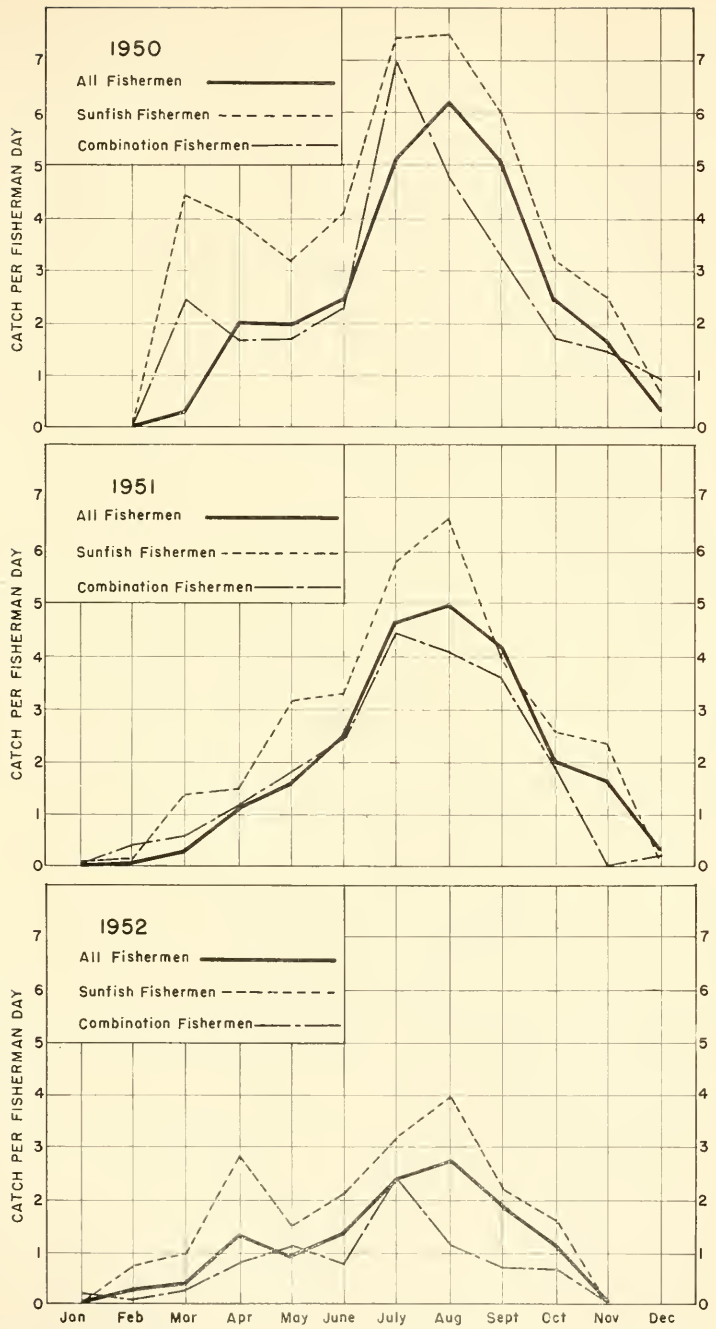


FIGURE 9. Quality of sunfish fishing at Millerton Lake, measured in catch of sunfish per fisherman day far each manth of 1950, 1951, and 1952; data segregated as to species sought

TABLE 6

Fishing Quality at Millerton Lake

	1945	1946	1947	1948	1949	1950	1951	1952
Catch of bass per fisherman day								
All fishermen	0.72	0.82	1.76	0.37	0.30	0.34	0.55	0.50
Shore fishermen					0.15	0.21	0.34	0.20
Boat fishermen					0.39	0.41	0.65	0.67
Bass fishermen						0.80	0.84	1.04
Sunfish fishermen						0.11	0.26	0.22
Combination fishermen						0.33	0.52	0.47
Catch of sunfish per fisherman day								
All fishermen	5.20	6.19	2.12	0.33	1.25	2.92	2.15	1.33
Shore fishermen					1.08	1.79	1.68	0.79
Boat fishermen					1.35	3.56	2.39	1.63
Bass fishermen						0.10	0.15	0.16
Sunfish fishermen						5.00	3.88	2.16
Combination fishermen						2.79	2.22	0.93
Total catch per fisherman day								
All fishermen	5.92	7.01	3.88	0.70	1.55	3.26	2.70	1.83
Limit catches[1]								
Bass, percent		0.3	2.2	0.3	0.8	1.5	2.6	2.5
Sunfish, percent			0.2		0.5	1.4	0.7	0.4
Zero catches								
Percent of all anglers		22.5	28.1	79.5	63.5	45.9	52.2	54.4
Percent of shore anglers		57.8	40.5	86.8	71.3	54.8	62.8	70.0
Percent of boat anglers		11.5	22.9	76.3	58.7	40.8	46.2	45.3

[1] Stated in percent of all fishermen interviewed.

In general, bluegill fishermen enjoy a single high peak of success in midsummer, although occasionally, as in 1950, an early season peak may occur. Such a peak is usually missed by the anglers because most people, by tradition, are then seeking bass.

Figures for catch per acre during each of the five years of intensive census are given in Table 2. Again, it is of interest to calculate on the basis of both the total area and the littoral area. The estimated yield in pounds of fish per acre of total surface varied from 2.6 during the low year of 1949 to 7.5 in 1951. The 1945 yield was undoubtedly higher, but no weights are available for that year. These values are extremely low, partly because such a high percentage of the lake does not contribute to fish production. Comparable figures for the littoral zone of about 400 acres show yields of from 28.8 to 82.3 pounds per acre for the same years. Although the latter values are much more representative of true fish production, they are still far short of the yield from shallow basin, constant level lakes.

Data on zero catches provide another measure of fishing quality. The annual calculations are shown in Table 6 and monthly values for a single representative year (1950) are shown in Figure 10. Trends in zero catches have an inverse relationship to catch per fisherman day but

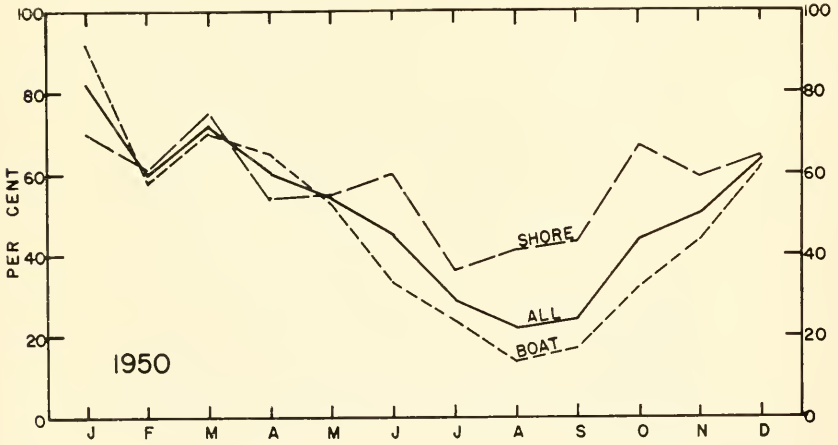


FIGURE 10. Percentage of fishermen with zero catches at Millerton Lake during each month of the sample year 1950; data segregated far shore and boat fishermen

reflect the same general differences in quality over and within the years of census.

Weight Data

Information on the trends in weight over the years are not available in precise terms. Notes with the original field data sheets indicate that bass size was acceptable during the first four years, with many 12- to 17-inch fish being included in the catch. In 1949, somewhat more than one year after the bass had begun their decline in numbers, the larger bass virtually disappeared and the fishery has since been supported primarily by two-year-old fish in the spring and by one-year-old fish in

the summer and fall. Older fish appear only occasionally. Although growth of the yearling fish is good, their size is still below even the most lenient level of acceptability, and complaints about the small size of the bass are frequent.

Weights of bluegill are much more difficult to trace back than those of bass because of their lesser importance in the eyes of the press and the sportsmen. Bluegill four-tenths of a pound and larger are classed as highly desirable by most anglers and are taken in considerable numbers by the more skillful bluegill fishermen (Figure 11). Bluegill larger than

FIGURE 11. Some fishermen are able to find the schools of large bluegill. These were taken from 30 feet of water during the sweltering late summer heat. *Photograph by Dana L. Abell, September 1, 1952.*

six-tenths of a pound are rarely seen. Large numbers of very small bluegill are present in the catch during the midsummer, however, and the average size of this species in the catch is therefore small. The problem in catching the large bluegll has always been one of locating the schools. These may be found in any part of the lake and, according to some of the experienced anglers, at any depth up to 30 feet. Given a lake of limited production with some 40 miles of shoreline, it is little wonder that many persons content themselves with the small bluegill, which usually frequent the shallow coves in large numbers.

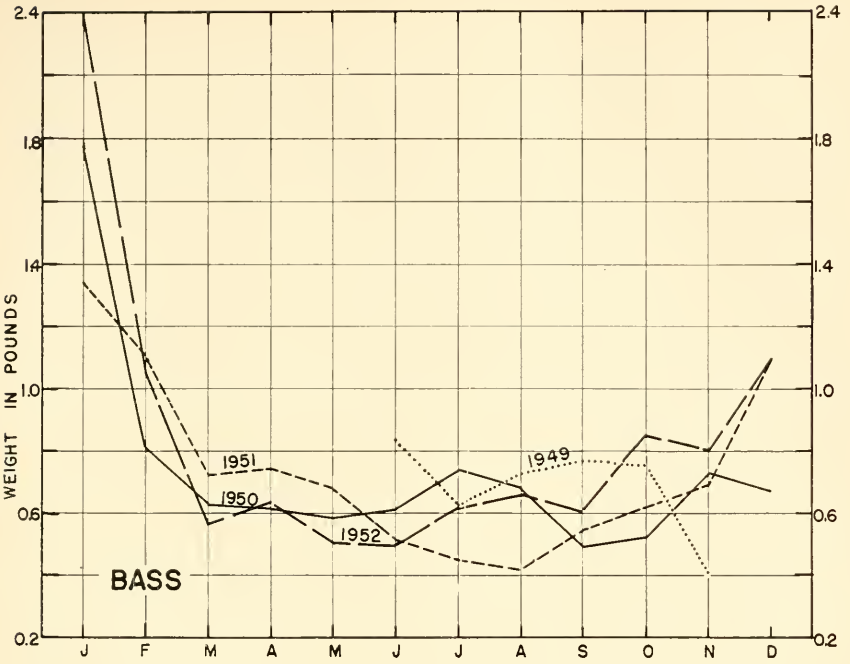


FIGURE 12. Manthly average weights of largemouth black bass taken at Millerton Lake, 1949 through 1952

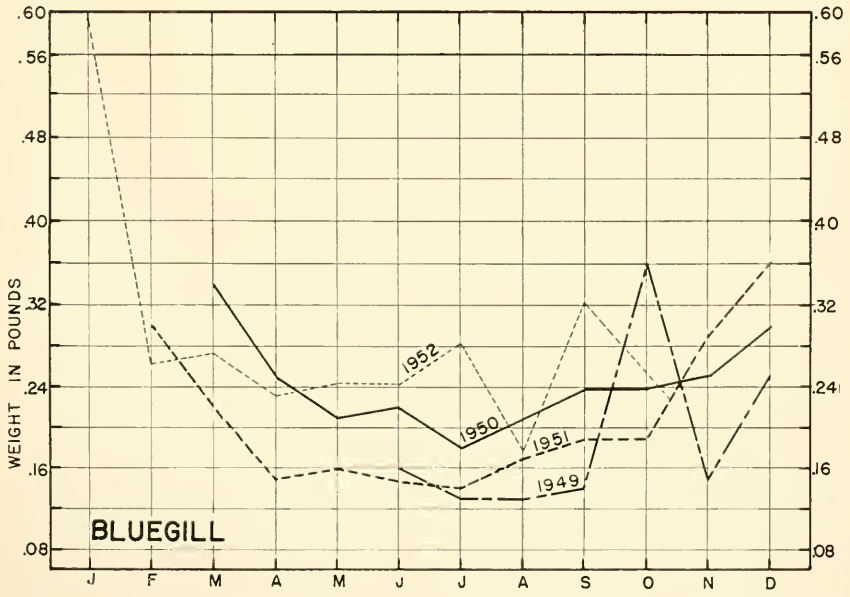


FIGURE 13. Monthly average weights of bluegill taken at Millerton Lake, 1949 through 1952

Average weights of each of the two main species of fishes are shown in Table 7 and Figures 12 and 13. The feature of most interest in the monthly average weights is the consistent dip of the curve for both bass and bluegill during the summer months. Winter fish are nearly always large. When angling improves, the weight drops off sharply, and as summer progresses it usually continues to decline for both species. After a midsummer low, bluegill begin a gradual return to the high winter average. Bass weights are rather inconsistent in the fall but usually reach a level somewhat higher than the earlier low.

TABLE 7

Average Weights in Pounds of Principal Species at Millerton Lake

	1949	1950	1951	1952
Largemouth black bass	0.74	0.63	0.67	0.57
Bluegill	0.17	0.22	0.16	0.23
Green sunfish	0.11	0.11	0.11	0.11

DISCUSSION

In a general way, changes in fishing quality at Millerton Lake since 1945 appear to have corresponded fairly closely with actual changes in fish populations.

The shape and neat interrelationships of the curves for catch of bass and of sunfish per fisherman day from 1945 through 1952 (Figure 5) suggest that fishing quality and presumably abundance of fish may fluctuate cyclically. Peaks at approximate four-year intervals, with bass lagging a year behind bluegill, seem to be indicated. It is, of course, too early to be sure that such a cycle exists, and more extended observations would be required to establish its existence definitely.

Forage Fish

Creel census data in combination with other information also further our knowledge of another phase of fish populations, namely, the forage situation. It has been apparent throughout this study that fishing quality for bass is often associated with the availability of forage. The spring peak in bass fishing comes at a time when forage size bluegill are noticeably lacking. The summer decline may be as much related to the presence of swarms of bluegill fry as it is to high temperature. Finally, the fall peak, if it comes, seems to be related to the disappearance of growth past forage size of the large summer crop of bluegill. The fall peak completely failed to appear in 1952, when forage conditions were good well into November.

It is conceivable that if a forage species that would provide food for bass throughout the year were present, a larger bass population would be supported. The experimental introduction of golden shiners (*Notemigonus chrysoleucas*) into Millerton Lake in early 1953 was an attempt to supply such a fish. It remains to be seen how much success this minnow will enjoy in weedless water and what effect year-round forage will have on bass fishing quality.

Regulations

On May 1, 1948, the year-round warmwater fishing season was initiated in the southern half of the State, including Millerton Lake, and the minimum size limit of nine inches for black bass was dropped. In order to compensate to a certain extent for this potential increase in take, in 1949 the bag limit was reduced from 10 to 5 fish, but the total effect was still one of liberalization and greater harvest because of the inclusion of the full spring peak in bass fishing. Relatively few fishermen at Millerton Lake ever take limits of bass, even at the lower limit, so the change in bag limit probably did little to reduce the total harvest.

In general, the fluctuations in angling success at Millerton Lake do not appear to be related to these changes. However, the decline in bass weight may have resulted in part from liberalization of the laws. In spite of the drop in fishing quality, bass weights apparently remained high until 1949, which was the first year when anglers could take full advantage of the spring peak in fishing quality (because of the year-round angling season). It would be expected, though, that if the provisions for increased harvest were to result in decreased size, a period soon after the relaxation of the rules would show a noticeable increase in catch. This was definitely not the case. It therefore seems probable that some other factor, such as lack of proper food, is responsible for the present small size of the bass. It is hoped that the introduction of a forage minnow will help this condition.

Everything considered, the present regulations appear to be satisfactory. Reproduction of bass is not being hampered by the present bag limit or by the taking of small fish. An increase in total harvest, especially among the sunfishes, would probably be desirable. This might be accomplished by making a much larger portion of the lake accessible to shore fishermen and by teaching the large numbers of inexperienced fishermen how to locate and catch fish in this lake. Measures are being taken to accomplish both of these ends.

ACKNOWLEDGMENTS

The 1945 census was directed and reported upon by Wm. A. Dill, who continued to supervise the work until 1950. S. M. Soule conducted the censuses from 1946 through 1948 and handled the preliminary analysis for those years. C. K. Fisher assisted from 1946 through 1948, directed the intensive program in 1949 and 1950, and made preliminary analyses for those two years; D. L. Abell continued this work in 1951 under the supervision of E. H. Vestal and handled the over-all analysis and writing of the present report in collaboration with C. K. Fisher.

The authors wish to thank the many persons who have aided in this project. Special thanks are due the United States Bureau of Reclamation and National Park Service for permission to establish census stations and Messrs. Wm. A. Dill, A. J. Calhoun, Leo Shapovalov, J. B. Kimsey, and E. H. Vestal for reviewing the manuscript. Seasonal aids who carried on most of the field work were J. L. Baxter, H. G. Brown, W. L. Craig, N. A. Jorgensen, Jr., C. S. Kabel, C. H. Meacham, R. A. Parnay, H. E. Pintler, H. D. Washburn, and R. F. Winter. Their per-

severance under frequently uncomfortable conditions and their many suggestions were especially valuable.

Finally, the writers express their thanks to the numerous anglers who have cheerfully provided the requested information.

SUMMARY

The fishery at Millerton Lake has been measured by creel census more or less continuously since this large, highly fluctuating foothill reservoir was first opened to fishing in 1945.

An excellent initial fishery (0.72 bass and 5.20 sunfish per angler day in 1945) lasted two years, following which fishing quality fell to an extreme low in 1948 (0.33 sunfish and an estimated 0.2 bass per angler day), but subsequently recovered in 1950 to about one-half the original quality. Size of both bass and bluegill has declined also and remains at a low level (average bass in 1951, 0.67 pound; bluegill, 0.16 pound). These changes seem to be related to the normal decline of fertility in new lake basins, although cyclical population fluctuations may also be involved.

Monthly catch records for 1949 through 1951 show peaks in fishing quality for bass in the spring and fall and for sunfish in midsummer. Angling effort is frequently not well correlated with the quality of bass angling, especially in the fall, when fairly good bass fishing is all but ignored. Sunfish effort and catch are better coordinated, probably because the peak is easily predicted.

A marked decline in weights of both bass and bluegill during the summer is noted. Differential activity of the various year classes of fish and, to a lesser extent, entry of yearlings into the catch are probably both involved.

Green sunfish have never been important either in numbers or size, even though there was a heavy initial stocking. They have never contributed more than 8 percent of the catch, and average size is about one-tenth pound.

In a typical year (1950) the lake received 8.1 fisherman days per surface acre and yielded 6.7 pounds of game fish. These are concentrated upon a littoral zone of approximately 410 surface acres. Applying total effort and catch to the littoral zone alone gives production figures of 87.4 fisherman days and 72.3 pounds per acre.

The decline of the Millerton Lake fishery is probably not related to the liberalization of regulations on warmwater fishing, although the two occurred at approximately the same time. Fishing quality started to fall before the rule changes could possibly have had any effect, and it has recovered noticeably since then.

It is concluded that in general the existing regulations are adequate.

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THE 1950 LARGEMOUTH BLACK BASS AND BLUEGILL TAGGING PROGRAM IN MILLERTON LAKE, CALIFORNIA[1]

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In May, 1950, an exploratory tagging study was initiated at Millerton Lake by the Department of Fish and Game to estimate the rates of harvest of largemouth black bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*). This project was one phase of a program to discover possible means of improving angling on waters of this type. This report summarizes the results.

Millerton Lake is a 5,000-acre impoundment created by Friant Dam on the San Joaquin River some 20 miles north of Fresno. It is subject to extreme fluctuations in water level, with resulting adverse effects upon the fish populations. The reservoir and the first year of its fishery have been described by Dill (1946).

Valuable assistance was received on this project from many individuals and organizations. William A. Dill gave valuable advice and Robert F. Winter, Harold G. Brown, and John Baxter aided with field work. Mr. Hugh Peyton, United States National Park Service Custodian of the recreational area and Mr. Jackson Saunders, boat concessionaire, actively supported the project. Assistance with publicity was rendered by Messrs G. W. Philpott and Cecil Phipps, local sportsmen. Particular thanks are due the Millerton Lake Sportsmen's Club and the Fresno County Sportsmen's Club for stimulating interest in the program by means of special publicity programs.

Numerous prizes were furnished by local sporting goods firms to stimulate interest in the program and to encourage the return of tags. These were awarded at a series of drawings from returned tags. A small token prize and an official Department of Fish and Game Commendation Card were awarded every angler returning a tag.

Between May 16 and June 16, 1950, 61 bass and 397 bluegill were tagged in all parts of the lake and released immediately at the point of tagging, as shown in Figure 1. Standard monel metal strap tags were used, size No. 3 on the bass and No. 1 on the bluegill. They were placed on the upper jaw over both the maxillary and premaxillary.

Only bass nine inches or longer and bluegill five inches or longer, total length, were tagged, in order to avoid using fish smaller than those ordinarily retained by anglers.

Practically all fish tagged were captured by shallow water seining. Two bass were caught by hook and line. A majority was tagged in the lower, expanded part of the lake, which is most suitable for seining.

[1] Submitted for publication March, 1953.

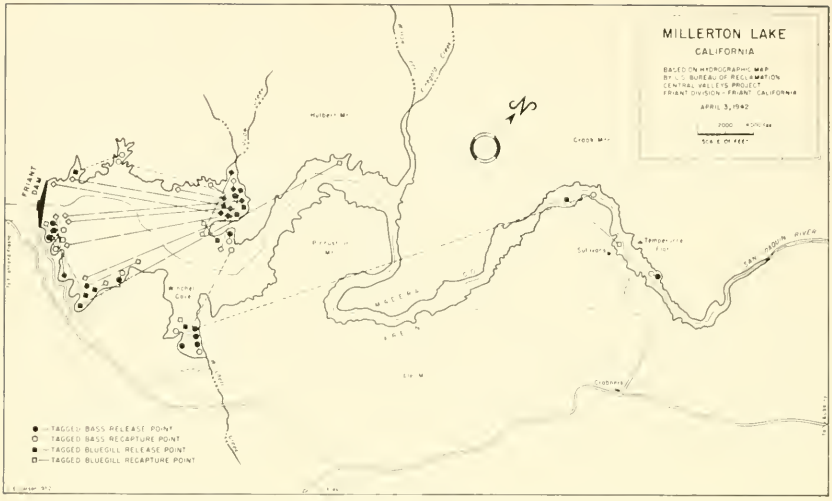

FIGURE 1. Map of Millertan Lake, showing points of tagging and recapture of largemouth black bass and bluegill

During the remainder of the calendar year of 1950, after the spring tagging period, tags from 12 bass and 19 bluegill were returned, amounting to 19.7 percent of the 61 bass tagged and 4.8 percent of the 397 bluegill tagged. Although the numbers involved are very small, these results are at least an indication that rates of harvest are not excessive at Millerton Lake.

Comparable rates have been reported for other waters. For example, in Norris Reservoir, Tennessee, Manges (1950) reported that the average return on tagged largemouth black bass, during five years of tagging, was 18.4 percent. This is not generally considered an excessive rate of harvest in such waters.

Tagged largemouth bass and bluegill in Millerton Lake move very little, judging from tags returned in 1950. The average movement from point of tagging was 1.2 miles for 12 bass and 1.4 miles for 19 bluegill. These mileages represent the shortest distances by water to point of recapture.

The longest journey of a bass was 8.8 miles, about half of the length of the reservoir, in a period of 88 days. The bluegill showing greatest movement traveled 4.0 miles in 34 days. Four bass and three bluegill had not moved from point of tagging when captured.

Even though these game fishes apparently move relatively little in Millerton Lake, angler concentration is probably insufficient in any one area of the reservoir to cause local depletion of the populations.

SUMMARY

A limited tagging study on largemouth black bass and bluegill was carried on by the California Department of Fish and Game at Millerton Lake in 1950. Out of 61 bass and 397 bluegill tagged, returns were

obtained on 12 bass (19.7 percent) and 19 bluegill (4.8 percent). Indications are that neither species is overexploited.

The average recorded movement from point of tagging to point of recapture was 1.2 miles for bass and 1.4 miles for bluegill.

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THE ELECTRIC FENCE AS AN AID IN FIELD STUDIES OF RODENTS AND THEIR ECTOPARASITES[1]

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INTRODUCTION

The electric fence has been used in several modified forms to retain or exclude certain animals. The following animals have been successfully fenced with electricity: Antelope were excluded from feeding areas in Yellowstone National Park (Grimm, 1938). Bears were prevented from destroying apiaries in California and Pennsylvania (Storer et al., 1938; Gerstell, 1938). Buffalo were excluded from overgrazed pasture in Yellowstone National Park (Maynard Barrows, in litt. 1937). Coyote nuisance was reduced in Texas (Nicholson, 1937). Deer were excluded from cultivated fields and orchards in Utah and Wisconsin (Doman, 1938; Nicholson, 1937). Elk were prevented from raiding haystacks in Washington (Nicholson, 1937). Fish have been excluded from irrigation ditches, canals and millraces by electrical fish stops (Burr, 1931; McMillan, 1928). Domestic livestock have been excluded from game plantings (Stoddard, 1938). Rabbits have been kept from vegetable gardens (Nicholson, 1937). Raccoons have been prevented from raiding grouse refuges (Darrow, 1938 in litt.). Pequegnat and Thomson (1949) used an electric fence in the Mojave Desert to study rodent population densities. They used voltage of sufficient strength to kill all animal species from a 96-gram *Dipodomys* to ants when they came in contact with the fence.

In 1952 the authors tested insecticides for control of ectoparasites on California ground squirrels, *Citellus beecheyi beecheyi* (Richardson) and *C. beecheyi fisheri* (Merriam). In this study it was important to know the number of animals per acre and to prevent migration of squirrels from one test area to another. A fence was designed which retained California ground squirrels and did not injure animals coming in contact with the electrically charged wires.

A mechanical and electrical barrier 37 feet square was constructed in the field and stocked with squirrels. After making certain changes, it seemed practical to test the effectiveness of this type of barrier on a larger scale. Five units were constructed during May and June, 1952; each unit enclosed an area of 44,100 square feet and was stocked with 150 ground squirrels. After nine months, no squirrels have climbed over the fence or dug under it.

[1] Submitted for publication April, 1953. This research project was supported by a contract (DA-49-007-MD-185) from the Research and Development Board, Office of the Surgeon General, Department of the Army.

THE ELECTRIC FENCE AND ITS CONSTRUCTION

A trench 18 inches deep and 12 inches wide was dug around the periphery of each field by a ditch digger. It is recommended that the fences be placed in the ground to a depth of 36 inches if they are to be used for one year or more or if other rodents such as gophers are present. Three-inch angle iron corner posts with braces were then cemented in post holes dug in the bottom of the trench (Figure 1). A one-inch pipe

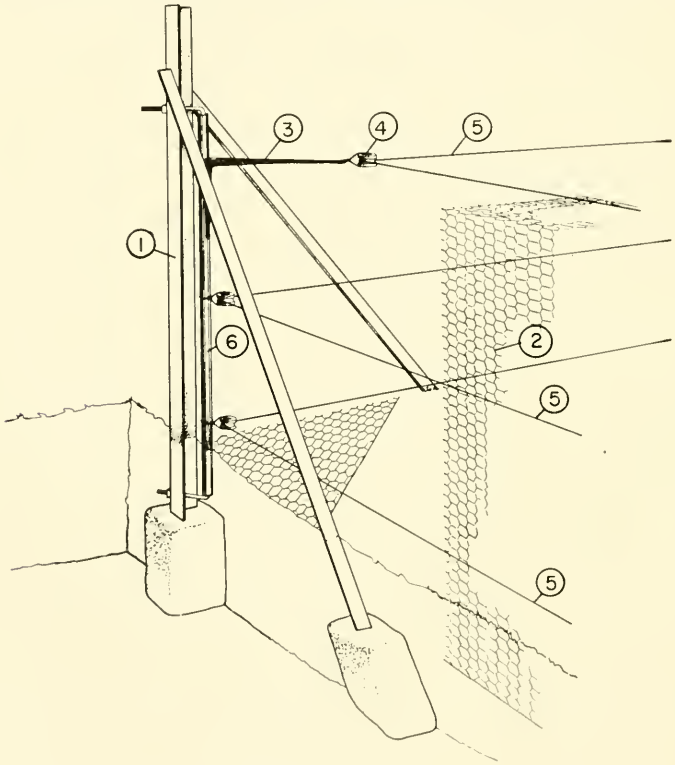

FIGURE 1. Cutaway of corner post. (1) corner post constructed of 3-inch angle iron; (2) wire netting, 1-inch mesh; (3) 12-inch shelf bracket; (4) circular type insulator used in fence corners only; (5) 13-gage aluminum wire, charged with electricity, is shown attached to the inside of the wire netting fence; (6) roller, a 1-inch iron pipe.

six feet long served as a roller (Figure 1, No. 6) around which the wire netting was pulled. The roller was held in place by two $\frac{3}{4}$-inch bolts bent at right angles as shown in Figure 1. The six-foot high wire netting (one-inch mesh) was pulled through each of the rollers in the four corners of the field. For each fence, six rolls of wire netting were needed. Before installation, the wire was spliced by weaving a strand of number six wire through the overlapping ends of the netting. Line posts seven feet long were subsequently driven along the inside wall of the trench at intervals of 15 feet (Figures 2 and 4).

Earth dug from the trench was replaced, burying the fence 18 inches deep. Twelve-inch shelf brackets were then bolted to the line post approximately three inches from the top of the posts as shown in Figure 2. These brackets served three purposes; (1) a support for the wire netting extending horizontally inward into the pens, (2) a support for the uppermost insulators and (3) a secure attachment of the wire netting

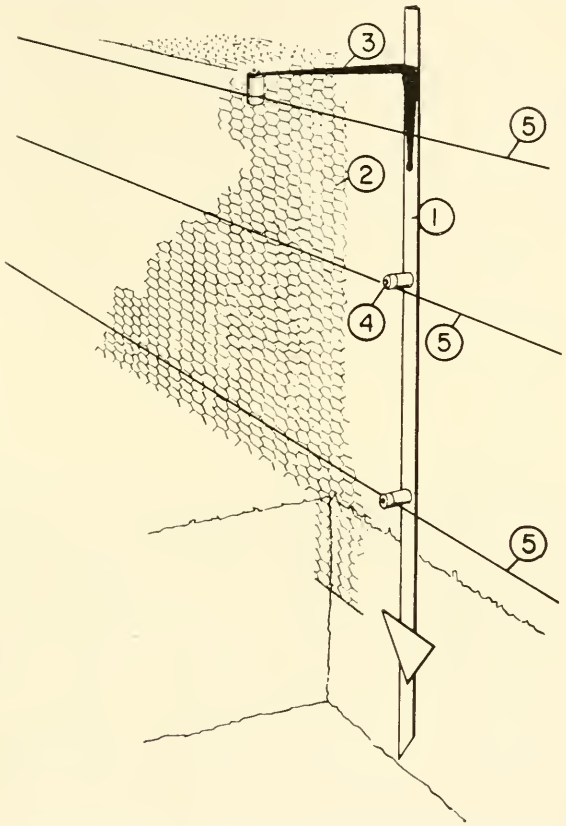

FIGURE 2. Cutaway at fence post. (1) 7-foot steel line post; (2) wire netting, 1-inch mesh; (3) 12-inch shelf bracket; (4) split-type insulator; (5) 13-gage aluminum wire charged with electricity.

to the upper portion of the line post. Shelf brackets were fastened to the corner rollers as indicated in Figure 1. In each fence corner a one-foot vertical cut was made in the top of the fence to permit horizontal folding of the fence in each corner. The fence was then folded over on itself and pulled tight by attachment to the braces of the corner posts. This procedure completed the overhang around the entire field.

Insulators were installed in the fence corners by attachment to the roller as shown in Figure 1. Split-type insulators were attached to line posts and shelf brackets by bolts as shown in Figure 2.

Smooth, single strand, 13-gage aluminum wire was stretched tight and held by a Burndy solderless connector. Three 13-gage aluminum

FIGURE 3. The fence charger is inside the fence and to the left of the corner post. Step ladders were used by research personnel for entry and exit fram fenced field. When not in use, the ladders were removed to prevent squirrels from escoping.

FIGURE 4. A portion of three fenced fields is shown in the fareground. An electric fence charger is visible in each fence corner. Lettuce crates used as observation posts for the squirrels are shown to the right and left of the driveway.

wires encircled the inside of each fence and were spaced as shown in Figures 1 and 2. One standard electric fence charger was placed inside each fenced field and connected to the insulated aluminum wires (Figures 3 and 4). This charger was powered by one six-volt dry-cell battery.

The electric fence chargers were placed inside the fields to prevent unauthorized persons from turning the current off. Research personnel entered the fields by step ladders as shown in Figure 3.

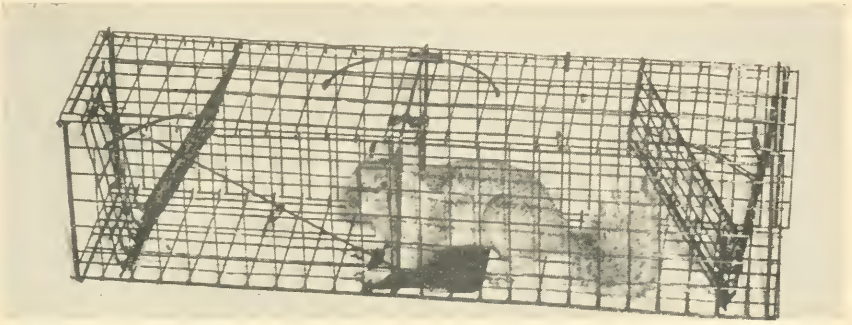

FIGURE 5. Of several live traps tested, the style shown was the most successful for capturing the California ground squirrel, *Citellus beecheyi*

RELEASE OF SQUIRRELS AND THEIR BEHAVIOR

Squirrels were trapped in collapsible wire traps (Figure 5). Seventy-one animals were trapped in one day using 35 of these traps.

In the central portion of each field, holes were dug to a depth of two and one-half feet by an auger-type post-hole digger. These holes were covered with cardboard or grass, and from four to six squirrels were released in each hole. This procedure was necessary to aid the squirrels in becoming psychologically adjusted to their new environment. Animals that did not have the security of temporarily prepared holes ran nervously about the fence lines and on occasion died of sun stroke in a relatively short period of time. Squirrels seldom used the holes constructed for them longer than a few days. Within one month, large squirrel colonies became established in dense clumps of mustard and Russian thistle. These colonies have had as many as 20 entrances in a burrow system. This amount of burrowing was accomplished in less than two months. One burrow system which had only four entrances was dug up and found to contain fifteen squirrels.

Most squirrel burrows excavated were found to extend downward to a depth of nearly three feet. Since the fence was buried one and one-half feet, the question can quite logically be asked, "Why didn't the squirrels burrow out under the fences?" There are three principal reasons why this did not happen: (1) The squirrels preferred dense clumps of weeds in the central portion of the fenced fields to barren ground along the fences. (Vegetation was removed from the fence lines during installation of the fence.) (2) On occasion, burrowing was started along the fences, usually in weedy patches. These attempts were

discouraged by flooding the burrow with water and plugging the entrances after exit of the squirrels present. Wide-spread burrowing was most active during the first weeks after squirrels were released in the fenced fields; once colonies were established there was little exploratory burrowing. (3) The electrically charged wire placed near the ground (Figures 1 and 2) repelled squirrels attempting to dig burrows near the fence.

CARE OF THE SQUIRREL POPULATIONS

Water was supplied to the squirrels in two-gallon chicken fountains during the hot, dry summer period.

Discarded green succulents were obtained from a local vegetable dealer and fed to the squirrels daily. This material consisted principally of lettuce and other greens. Seeds of several species of weeds and grasses were present and the following were readily eaten by squirrels: *Hordeum murinum* L., *Brassica incana* Meigen, and *Chenopodium album* L. Squirrels born in the laboratory have been reared to maturity without free water, their diet consisting of lettuce, meat and grains.

Soon after release into the fenced fields, the squirrels' behavior indicated that observation points were desired. Five such points were established per acre. Each unit consisted of three lettuce crates stacked together forming an elevated stand two feet high (Figure 4). When danger was apparent squirrel "sentries" on the crates signaled to other squirrels feeding in the vegetation. After establishment of these observation points, the behavior pattern of the squirrel population apparently became more psychologically secure and the desire to escape seemed to be markedly reduced.

BENEFITS DERIVED FROM THE ELECTRIC FENCE

The electric fence was developed to fill a need existing in insecticide studies concerned with the control of ectoparasites on ground squirrels. Results of the insecticide studies have been accepted for publication elsewhere.

Continued use of the electric fence in insecticide studies is indicated by the following significant advantages:

1. Ecological field variables were reduced to a minimum with respect to temperature, humidity, host food, soil type, soil pH and vegetation cover. This was made possible by erecting all the electrical fences in a similar ecological environment which was previously inhabited by ground squirrels.
2. High host-density has resulted in a high flea index. This high parasite index was ideal for comparison of treated and untreated rodent populations.
3. A sharp concise index was obtained at given intervals because a large number of squirrels were examined in a relatively short period of time.
4. Greater accuracy was possible in applying insecticides because the burrows were not in brushy and inaccessible terrain. Ground squirrels frequently inhabit irregular terrain which may be overgrown with dense vegetation.

5. Experimental squirrel populations were not disseminated or disturbed by nonavian predators.
6. Squirrels were prevented from migrating into experimental fields from surrounding untreated areas.

THE ELECTRIC FENCE AS A BARRIER TO RATS

Rattus rattus rattus Linnaeus, *Rattus norvegicus* Erxleben, albinos and hybrids were trapped from a local dump and used as experimental animals. Eighteen rats were confined in a pen 15 feet square for a continuous period of 24 hours; none escaped. This experiment was repeated twice with the same results.

Construction of this electric and wire netting fence was similar to that of the squirrel pens. Principal differences were: (1) One foot of the wire netting was turned inward horizontally at the ground level. A light covering of earth held down and covered the turned-in lower edge. (2) Eight inches of netting along the top of the fence was turned inward horizontally with two additional inches turned down vertically on the inner edge of the overhang. (3) An electric wire was placed in the center of the overhang instead of at the edge as in the squirrel pens. Two electric wires were attached to perpendicular sections of the fence as shown in Figure 6. Few rats were successful in climbing over the

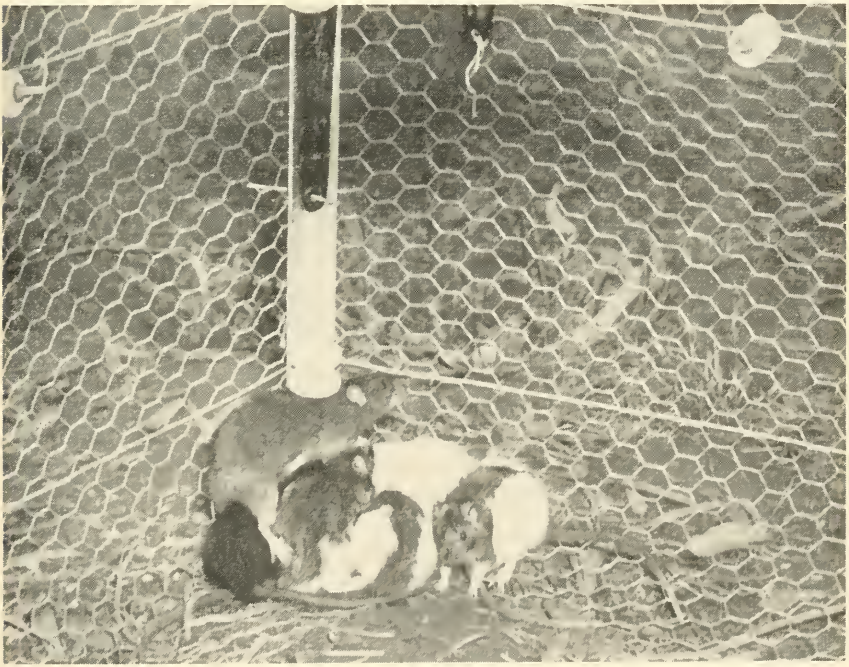

FIGURE 6. Rats trapped from a dump are retained below the lowest of three electrically-charged aluminum wires. The rats soon became conditioned and were careful not to come in contact with the charged wires.

first electric wire and then for only a few seconds (Figure 6). Studies are in progress to determine if the electric fence is a practical method of protecting stored products which are susceptible to rat damage.

SUMMARY

A method of constructing a mechanical and electrical fence has been perfected to retain or exclude the California ground squirrel *Citellus beecheyi beecheyi* (Richardson) and *C. beecheyi fisheri* (Merriam).

Insecticide studies concerned with ectoparasite control on the California ground squirrel have been greatly aided by confining the rodents in fields fenced with electricity. This procedure has reduced field variables to a minimum with respect to temperature, humidity, soil type, soil pH, host density, host food and migration of squirrels between study areas.

Rats of the genus *Rattus* have been confined to a pen 15 feet square by the use of a specially designed electric fence. Studies are in progress to determine if the electric fence is a practical method of protecting stored products which are susceptible to rat damage.

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RESPONSE OF BRUSH SEEDLINGS TO SPRAYS OF 2,4-D AND 2,4,5-T ON BURNED CHAMISE AREAS[1]

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INTRODUCTION

In manipulating chamise brush for game, the control of brush seedlings on areas where fire is used may well be an important phase of management. Following fires, seedlings usually appear in great abundance and unless these are retarded they soon develop into a stand of brush too dense for optimum utilization. Chemical sprays offer a possible means of brush seedling control.

From 1948 through 1952 the use and effects of 2,4-D and 2,4,5-T on brush seedlings in chamise areas in Lake County, California, were studied. Although considerable experimentation has been done with sprays on mature brush plants, relatively little attention has been given to seedlings. Leonard (1952b), however, found that a few chamise seedlings usually remained on plots sprayed with less than four pounds per acre of isopropyl ester of 2,4-D and 2,4,5-T with water and diesel oil as the diluent. Only the plots he sprayed with 2,4,5-T at four pounds per acre in diesel oil gave 100 percent kill of seedlings. Plots sprayed with two pounds of 2,4,5-T with oil emulsions and oil as the diluents had less than 10 percent as many chamise seedlings as the checks.

The economic feasibility of brush seedling control by hormone sprays was not covered in this study. However, Leonard (1952a) has found the cost of spraying chamise brushlands in Southern California to be about $5 per acre.

Investigations by Biswell, et al. (1952), have indicated three other possible means of brush seedling control: (1) Reseeding desirable forage plants to produce a stand which will offer enough competition to choke out many of the brush seedlings. (2) Reburning in two to four years after a first fire to destroy most of the seedlings. (3) Management whereby the area burned is not greater than that which can be fully utilized by deer. Thus far, where fire is used, a combination of reseeding and management has proven to be the most satisfactory way of controlling brush seedlings.

RESULTS OF EXPERIMENTAL WORK

Treatments Started in 1948

In August, 1948, 65 mil-acre plots (6.6 feet x 6.6 feet) were established in Lake County to study the effects of 2,4-D sprays on chamise and associated brush seedlings. All the plots were located on a burn of the pre-

[1] Submitted for publication May, 1953. Federal Aid in Wildlife Restoration Act, California Project W-31-R.
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TABLE 1

Original Seedling Counts Before Spraying (August, 1948) With Various Solutions of 2,4-D and Final Recount After Spraying (August, 1950). Three Mil-acre Plots for Each Treatment.

Treatment	Chamise			Wedgeleaf ceanothus			Wavyleaf ceanothus			Manzanitas			Yerba santa			Total, all seedlings		
	8/10/48	8/29/50	Percent survival	8/10/48	8/29/50	Percent survival	8/10/48	8/29/50	Percent survival	8/10/48	8/29/50	Percent survival	8/10/48	8/29/50	Percent survival	8/10/48	8/29/50	Percent survival
Heavy sheep use followed by heavy deer use																		
Amine H_2O 1# A.	154	17	11.0	11	6	54.6	6	2	33.3	34	5	14.7	6	1	16.7	211	31	11.0
Amine H_2O 2# A.	155	7	1.5	10	4	40.0	5	.3	6.0	13	.3	2.3	27	2	7.4	510	13.6	2.7
Amine H_2O 4# A.	421	3	.7	9	2	22.2	16	1	6.3	35	1	2.9	7	1	14.3	488	8	1.6
Ester H_2O 1# A.	187	16	8.6	40	12	30.0	30	8	26.8	16	2	12.5	10	2	20.0	283	40	14.1
Ester H_2O 2# A.	195	11	7.2	20	8	40.0	20	7	35.0	4.3	3	69.2	19	1	5.3	258	33	12.8
Ester H_2O 4# A.	196	25	12.8	7	3	43.0	1.3	1	75.0	.3	0	0.0	82	2	2.4	286.6	31	10.8
Ester oil 1# A.	207	29	14.0	21	7	33.4	12.3	4	32.4	17	3	17.7	20	1	5.0	277.3	44	15.8
Ester oil 2# A.	161	6	3.6	22	5	22.8	6	.3	5.0	28	2	7.1	6	.3	5.0	223	13.6	6.1
Ester oil 4# A.	375	10	2.7	8	1	12.5	3	0	0.0	13	0	0.0	33	0	0.0	433	11	2.5
Diesel oil 5 gal. A.	278	76	27.4	20	8	40.0	25	15	60.0	45	21	46.6	7	4	51.2	375	124	33.6
Check plots	240	39	16.2	13	4	30.8	7	4	57.2	22	16	72.8	25	14	57.0	307	77	25.1
Slight deer use																		
Amine H_2O 1# A.	136	14	10.3	.3	.3	100.0	7	1.3	18.6	.3	0	0.0	13	0	0.0	186.6	15.6	8.3
Amine H_2O 2# A.	151	7	4.6	2.0	0	0.0	30	10	33.3	1.0	0	0.0	29	0	0.0	213.0	17	7.9
Amine H_2O 4# A.	223	4	1.8	.7	.3	43.0	2	.3	15.0	.3	0	0.0	4	0	0.0	230.0	4.6	2.0
Ester H_2O 1# A.	265	15	5.7	.7	1.0	100.0							3	0	0.0	268.7	16	5.9
Ester H_2O 2# A.	201	16	8.0	2.0	.3	15.0	44	13	29.6	.3	.3	100.0	57	0	0.0	301.3	29.6	9.7
Ester H_2O 4# A.	286	28	9.8	9.0	1.0	11.1	20	6	30.0	4.0	.6	15.0	8	0	0.0	327	35.6	10.9
Ester oil 1# A.	112	37	26.0	18.0	4.0	22.2	55	7	12.7	2.0	1.3	65.0	1	0	0.0	218	50	22.9
Ester oil 2# A.	202	37	18.3	39.0	7.0	18.0	12	2	16.7	1.0	.3	30.0	4	0	0.0	258	57	22.1
Ester oil 4# A.	200	6	3.0	15.0	1.0	6.7	81	11	13.1				5.3	0	0.0	301.3	18	5.9
Check plots	194	52	26.8	7.0	1.5	21.4	24	19	79.1	.2	0	0.0	19	6.5	13.3	274.2	79	28.8

vious fall and the seedlings were of current year origin. Half of the plots were in an area that was heavily utilized by sheep and possibly by some deer until the first of July and, after that, used heavily by deer; the other plots were located in an area that was lightly utilized by deer.

The plots were selected to obtain a large number of seedlings so that all important species in this area might be amply represented. A total of 19,427 seedlings were counted on the 65 mil-acre plots. Amine salts of 2,4-D in water, and isopropyl ester of 2,4-D in both water and oil were applied with a small hand spray gun at the rates of one, two, and four pounds of parent acid in 10 gallons of water and five gallons of oil solution per acre. It is thought that all seedlings were covered with the spray solutions. Recounts to determine seedling survival were made in December, 1948, May, 1949, December, 1949, and August, 1950. The original seedling count before spraying and the final recount are given in Table 1. The natural survival of seedlings drops sharply the first year, as much as 50 percent, and then levels off the second year. Likewise, the mortality caused by the sprays was greatest in the first year and was less noticeable in the second year. At the end of two years the survival of some species on the check plots was less than 20 percent.

The figures giving the totals for all seedlings indicate that the 2,4-D sprays reduced seedling survival in all cases. However, diesel oil spray at the rate of five gallons per acre was totally ineffective in reducing seedling survival. The amine of 2,4-D proved more effective than any other mixture. In most cases the stronger concentrations of 2,4-D gave the best kill. There seemed to be little or no correlation between the percentage of kill of seedlings by the sprays and the degree of utilization by sheep and deer. In the case of yerba santa, however, a greater kill was obtained on the lightly utilized plots where competition from other species was greatest. This species is very sensitive to competition.

Treatments Started in 1949

In 1949, another study was started to further test the effectiveness of sprays in destroying brush seedlings. All brush seedlings were counted on 106 mil-acre plots. One set of 48 spray plots and five check plots were located in a two-year-old burn that had been heavily used by sheep and deer the first year after the fire. Another set of the same number was placed in a one-year-old burn with seedlings of the current year. Sheep had heavily used this latter area in the spring. Amine salts of 2,4-D, isopropyl ester of 2,4,5-T, and a mixture with equal amounts of amine salts of 2,4-D and isopropyl ester of 2,4,5-T were applied at per acre rates of 0.75 pound, 1.5 pounds, 3.0 pounds, and 4.5 pounds of parent acid. A total of 16 different combinations was used on each set of the 48 plots. These were applied in a solution consisting of four gallons of water to one gallon of oil. This solution was used at the rate of $3\frac{3}{4}$ gallons per acre, applied carefully with a small hand spray gun so as to cover all seedlings. A small amount of detergent, about one ml. of 1 percent solution of Unox per 60 mls. of spray, was added to the above to increase the effectiveness of sprays containing amine salts of 2,4-D.

Spraying was done in July between 4 and 8 a.m. when there was little air movement. To make sure that the correct application was given each plot and to minimize the effect of drift, three plywood panels four by

TABLE 2

Results With 2,4-D and 2,4,5-T on Brush Seedling Plots. Seedling Numbers for Each Spray Treatment Based on Three Mil-acre Plots; Those for Checks on Five Mil-acre Plots. (Sprayed July, 1949; Recounts Made in December, 1949, and July, 1950)
One-year-old Burn

Treatment	Chamise			Wedgeleaf ceanothus			Wavyleaf ceanothus			Manzanita spp.			Yerba santa			Total, all seedlings		
	No.	Percent survival		No.	Percent survival		No.	Percent survival		No.	Percent survival		No.	Percent survival		No.	Percent survival	
	7/49	12/49	7/50	7/49	12/49	7/50	7/49	12/49	7/50	7/49	12/49	7/50	7/49	12/49	7/50	7/49	12/49	7/50
2,4-D ¾ #/A.	1,167	18.9	3.0	9	66.7	22.2	14	21.4	*28.6	15	13.3	0.0	43	23.3	14.0	1,242	19.4	3.8
Amine 1½ #/A.	1,014	4.0	1.9	4	25.0	0.0	15	6.7	0.0	13	15.4	0.0	69	4.3	*16.0	1,115	4.4	2.7
Amine 3 #/A.	243	4.1	*7.8	11	9.1	0.0	7	0.0	0.0	4	0.0	0.0	77	0.0	*18.2	342	3.2	*9.6
Amine 4½ #/A.	245	1.2	*6.5	10	0.0	*20.0	4	0.0	0.0	4	0.0	*25.0	10	0.0	*70.0	273	1.1	*9.5
2,4,5-T ¾ #	821	8.6	0.4	3	0.0	0.0	3	0.0	0.0	7	57.1	11.3	18	5.6	*66.7	852	8.9	1.9
2,4,5-T 1½ #	911	14.6	1.0	10	20.0	20.0	3	0.0	0.0	7	0.0	0.0	22	13.6	*18.2	953	14.5	1.6
2,4,5-T 3 #	732	16.1	0.0	15	13.3	0.0	49	8.2	0.0	2	0.0	0.0	83	0.0	*18.1	881	14.1	1.7
2,4,5-T 4½ #	972	4.1	0.4	---	---	---	91	1.1	*3.3	20	10.0	10.0	43	4.7	*81.4	1,126	4.1	3.9
2,4,5-T ¾ #	2,029	18.8	2.0	23	56.5	13.0	57	10.5	3.5	30	10.0	3.3	46	10.9	*40.0	2,185	18.7	2.9
plus 1½ #	3,200	4.9	0.2	19	21.1	15.8	104	8.7	3.8	72	18.0	*20.8	38	0.0	*39.5	3,433	5.3	1.3
2,4-D 3 #	1,695	4.1	0.2	12	16.7	0.0	25	8.0	0.0	8	0.0	*25.0	19	0.0	*89.5	1,759	4.2	1.3
Amine 4½ #	1,446	1.8	0.1	17	11.8	11.8	15	0.0	0.0	7	0.0	0.0	11	0.0	*236.2	1,496	1.9	2.0
2,4,5-T ¾ #	1,897	14.1	0.9	17	17.6	0.0	64	1.6	0.0	33	15.2	9.1	2	50.0	*400.0	2,013	13.8	1.4
plus 1½ #	622	6.7	0.3	5	0.0	*20.0	------	------	------	2	0.0	0.0	10	20.0	*120.0	639	6.9	2.1
2,4-D 3 #	1,315	3.4	0.3	2	0.0	0.0	31	6.5	3.2	15	13.3	0.0	16	0.0	*106.2	1,379	3.5	1.6
Ester 4½ #	382	5.2	0.0	3	0.0	*33.3	2	0.0	0.0	1	0.0	100.0	9	11.1	*200.0	397	5.3	5.3
Checks	2,679	50.0	10.4	58	43.1	20.7	112	12.5	26.1	67	22.3	7.5	75	34.6	32.0	2,991	47.5	11.6

* Indicates emergence of new seedlings between 12/49 and 7/50.

TABLE 3

Results With 2,4-D and 2,4,5-T on Two-year-old Brush Seedlings. Seedling Numbers for Each Spray Treatment Based on Three Mil-acre Plots; Those for Checks on Five Mil-acre Plots. (Sprayed July, 1949; Recounts Made in December, 1949, and July, 1950)

Two-year-old Burn

Treatment	Chamise			Wedgeleaf ceanothus			Wavyleaf ceanothus			Manzanita spp.			Yerba santa			Total, all seedlings		
	No.	Percent survival		No.	Percent survival		No.	Percent survival		No.	Percent survival		No.	Percent survival		No.	Percent survival	
	7/49	12/49	7/50	7/49	12/49	7/50	7/49	12/49	7/50	7/49	12/49	7/50	7/49	12/49	7/50	7/49	12/49	7/50
2,4-D 3/4 # A.	711	61.2	69.2	38	60.5	57.9	91	47.3	48.3	117	85.4	78.7	38	65.7	65.7	998	62.9	67.8
Amine 1 1/2 # A.	711	66.5	70.8	33	75.7	69.7				32	78.4	56.3	39	89.7	79.4	815	71.4	70.7
Amine 3 # A.	731	57.9	51.6	47	80.8	74.5	3	66.7	33.3	64	43.7	28.1	20	100.0	105.0	868	59.2	52.3
Amine 1 1/2 # A.	691	35.1	21.9	76	56.5	60.5	33	60.6	57.6	65	26.2	23.1	11	81.8	63.6	879	38.1	27.2
2,4,5-T 3/4 #	281	57.1	56.7	9	22.2	22.2	49	75.5	61.3	1	50.0	50.0	52	59.6	41.3	399	58.8	51.7
2,4,5-T 1 1/2 #	172	59.9	52.4	16	50.0	25.0	87	83.9	72.4	52	44.2	38.5	62	82.3	67.8	389	66.4	56.4
2,4,5-T 3 #	336	29.5	24.4	2	50.0	50.0	175	42.9	41.2	184	27.7	22.3	31	54.8	48.4	728	33.4	29.1
2,4,5-T 4 1/2 #	505	30.5	23.4	13	38.4	15.4	30	76.6	50.0	1	0.0	0.0	16	63.0	58.7	595	35.5	27.2
2,4,5-T 3/4 #	674	14.7	63.2	101	83.1	37.6	19	52.6	73.7	29	14.8	169.0	11	63.6	81.9	834	19.8	61.3
plus 1 1/2 #	797	10.9	35.6	65	36.9	26.2				8	25.0	25.0	11	72.7	54.6	881	40.9	35.0
2,4-D 3 #	745	34.1	37.8	39	51.3	28.2	1	100.0	100.0	131	32.8	18.3	15	80.0	53.4	931	35.6	34.9
Amine 1 1/2 #	885	21.9	17.5	39	25.6	7.7				58	18.9	8.6	3	0.0	0.0	985	21.8	16.6
2,4,5-T 3/4 #	439	62.6	47.2	84	54.7	34.5	4	0.0	50.0	2	100.0	100.0	20	15.0	35.0	549	60.5	45.0
plus 1 1/2 #	516	59.8	53.5	29	62.0	48.3							36	75.0	63.9	611	60.8	53.8
2,4-D 3 #	334	39.1	31.4	37	48.6	18.9				1	100.0	100.0	15	73.3	53.4	487	40.2	31.2
Ester 4 1/2 #	365	28.5	23.6	61	42.6	32.8	3	0.0	33.3	2	50.0	50.0	33	72.7	90.9	464	33.4	29.7
Checks	1,024	57.8	61.9	151	78.1	47.7	105	83.8	81.9	105	59.0	57.4	82	91.5	79.3	1,467	63.7	62.6

eight feet were placed around each plot before spraying and left in place until the spray had settled.

A summary of the results of the spraying is presented in Tables 2 and 3. A total of 23,079 seedlings was counted on 53 mil-acre plots on the one-year-old burn and 12,946 seedlings on the same number of plots on the two-year-old burn. The number of seedlings for each treatment is based on three replications except for the checks, which consist of seedling numbers from five plots.

The results of this test show the sprays to be much more effective on one-year-old than on two-year-old brush seedlings. As with the first series of treatments, kills were generally greater for the more concentrated solutions. Delayed germination of brush seedlings on recent burns was observed for all species. This fact indicates that if seedlings are treated the first year, when treatment is most effective, new seedlings may still appear the next year.

Treatments Started in 1950

Studies on the possible use of sprays in conjunction with reseeding burned chamise brushlands were started in 1950. Three blocks with different densities of grass cover were selected in an area of chamise brush burned and reseeded with annual ryegrass in the fall of 1949. Ryegrass was seeded at the rate of six pounds per acre and the resulting cover consisted principally of ryegrass where the stand was most dense and of wild annuals, chiefly foxtail fescue, where the stand was the least dense.

TABLE 4

Survival of Brush Seedlings of Chamise, Wedgeleaf Ceanothus, and Yerba Santa Sprayed With a Combination of 2,4-D and 2,4,5-T Under Good (25%), Fair (15%) and Poor (5%) Densities of Grass on Reseeded Burned Chamise Brushland. Sprayed 1950, Recounts Made 1951

Species	Sprayed plots			Check plots		
	7/50	7/51	Percent survival	7/50	7/51	Percent survival
Grass Density 25% (good)						
Chamise	161	48	29.8	53	14	26.4
Wedgeleaf C	27	1	3.7	9	2	22.2
Yerba santa	33	6	18.2	4	1	25.0
Totals	221	55	24.9	66	17	25.8
Grass Density 15% (fair)						
Chamise	331	53	16.0	95	32	33.7
Wedgeleaf C	92	2	2.2	28	4	14.3
Yerba santa	420	27	6.4	108	28	21.9
Totals	843	82	9.7	231	64	27.7
Grass Density 5% (poor)						
Chamise	805	102	12.7	158	49	31.1
Wedgeleaf C	168	22	13.1	69	15	21.7
Yerba santa	714	120	16.8	257	103	40.1
Totals	1,687	244	14.5	484	167	34.5

One block had an estimated grass density of less than 10 percent, one varied from 10 to 20 percent, and the third was greater than 20 percent. The areas selected were located on a chamise slope of a southeast exposure and soils were comparable. Four $\frac{1}{400}$-acre strips measuring 3.3 by 33 feet were laid out at random within each of these blocks and three plots in each block were sprayed in July with a combination of 2,4-D and 2,4,5-T at the per acre rate of one pound of total acid in a 10-gallon water-oil solution consisting of eight gallons of water to two gallons of oil. One strip selected at random in each block served as a check and recounts were made to determine the effectiveness of the sprays in destroying brush seedlings under different densities of grass cover. The total number of brush seedlings recorded on these strips before and after spraying is given in Table 4.

In these studies the relative survival of brush seedlings when sprayed with a combination of 2,4-D and 2,4,5-T was greatest where the grass density was highest, and was intermediate where the grass density was lowest. The low kill of seedlings in the plots with the highest grass density might have been due to some protection provided by the grasses, and also to a drier soil moisture situation. However, these possible factors were not evaluated. The differences in number of brush seedlings at the start and end of the study for the check plots are in agreement with other studies (Biswell, et al., 1952) showing that grasses in high densities suppress the establishment of brush seedlings regardless of other treatment.

Treatments Started in 1951

Studies in 1951 were enlarged to include spraying $\frac{1}{10}$-acre strips on burned chamise brushlands seeded to a 1:1 mixture of hardinggrass and smilo at the rate of 8 pounds per acre. Strips 100 feet by 43.56 feet with the long axis up the slope were used. The area of burned chamise brushland extended over a small watershed with both northwest and southeast exposures. A strip on each exposure was sprayed in the middle of May, June, and July. At the time of spraying, five permanent mil-acre plots were established on the sprayed strips as well as on adjoining check areas of the same size. The brush seedling counts from these areas before and one year after spraying are included in Table 5.

Survival of brush seedlings was much lower when the spraying was done early in the season. May applications gave the best results on both exposures. June was satisfactory on the northwest but apparently too late for the drier southeast slope. Spraying in July was equally unsatisfactory on both exposures. Offord (1949), in working with Ribes, found that this plant is more easily killed by sprays in May than in July or August. A striking feature of these results is the low survival of brush seedlings in 1951-52 on the check plots. It is thought that frost heaving accounted for much of this mortality, as is often the case with reseeded grasses (Biswell, et al., 1953). Frost heaving is generally more severe on the northerly exposures. The unusually heavy losses on the check plot for the strip in June may have been caused by local variation in aspect as it was on a more westerly slope than the areas sprayed in May and July.

TABLE 5

Summary of Effect of 2 4,5-T on Brush Seedlings Sprayed at Different Dates (May 15, June 15, July 14) on Northwest and Southeast Exposures. Sprayed at Rate of 1 lb. of Acid per Acre in 10 gals. of Water: Oil Solution in Ratio of 4:1. Each Entry Based on Five Mil-acre Plots.

	Sprayed plots		Percent survival	Check plots		Percent survival
Northwest Exposure	5/51	7/52		5/51	7/52	
Chamise	----	----		----	----	----
Wedgeleaf C.	12	0	0.0	29	1	3.4
Deerbrush*	168	1	0.6	155	22	14.2
Others	19	1	5.3	41	10	24.4
Totals	199	2	1.0	225	33	14.7
Southeast Exposure						
Chamise	234	3	1.3	614	62	10.1
Wedgeleaf C.	67	3	4.5	188	12	6.4
Deerbrush	----	----	----	----	----	----
Others	2	0	0.0	17	0	0.0
Totals	303	6	2.0	819	74	9.0
Northwest Exposure	6/51	7/52		6/51	7/52	
Chamise	179	4	2.2	224	13	5.8
Wedgeleaf C	47	0	0.0	37	1	2.7
Deerbrush	70	0	0.0	56	0	0.0
Others	17	0	0.0	12	4	33.3
Totals	313	1	1.3	329	18	5.5
Southeast Exposure						
Chamise	1,120	110	9.8	1,362	337	24.7
Wedgeleaf C.	151	9	6.0	69	14	20.3
Deerbrush	----	----	----	45	0	0.0
Others	37	2	5.4	18	1	5.6
Totals	1,308	121	9.3	1,494	352	23.6
Northwest Exposure	7/51	7/52		7/51	7/52	
Chamise	5	2	40.0	8	2	25.0
Wedgeleaf C.	16	2	12.5	34	1	2.9
Deerbrush	49	4	8.2	30	5	16.7
Others	24	7	29.2	15	10	66.7
Totals	94	15	16.0	87	18	20.7
Southeast Exposure						
Chamise	164	31	18.9	571	181	31.7
Wedgeleaf C	46	4	8.7	64	19	29.7
Deerbrush	3	1	33.3	1	0	0.0
Others	4	2	50.0	8	2	25.0
Totals	217	38	17.5	644	202	31.4

* (Ceanothus integerrimus.)

SUMMARY AND CONCLUSIONS

In manipulating brush for game, the control of seedlings after fire is an important phase of management. Brush seedlings usually appear in great abundance after fire and without some means of control they may develop into a stand of brush too dense for optimum utilization.

The control of brush seedlings with sprays of 2,4-D and 2,4,5-T on burned chamise brushlands in Lake County was tested over a four-year period. Many of the seedlings were killed by the sprays but some of every species survived. The number surviving may be a small percentage of the original number but often these would be enough to produce a full stand of brush at maturity. Other possible means of brush seedling control have been reported by Biswell, et al. (1952).

The economic feasibility of brush seedling control by hormone sprays was not covered in this study. However, Leonard (1952a) has found the cost of spraying chamise brushlands in Southern California to be about $5 per acre.

Principal results of the study may be summarized as follows:

1. Sprays were more effective on current year seedlings than on two-year-old seedlings.
2. In all treatments new seedlings appeared the second year after spraying current year seedlings, thus tending to mask the effect of the sprays.
3. The higher concentrations of sprays were more effective than the weaker ones.
4. Seedlings were more susceptible to sprays in early spring when the soil was moist than later when the soil had dried.
5. Species were susceptible to sprays in this approximate order: yerba santa, chamise, wavyleaf ceanothus, manzanita, and wedgeleaf ceanothus.
6. Results with sprays indicate that other means of brush seedling control for game, such as reseeding and grazing management, are more practical and effective than hormone sprays at this time. However, when sprays are used they should be applied to current year seedlings, in the early spring after seasonal germination is complete, and at the approximate rate of 4 pounds of acid per acre.

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REPORT ON SOUTHERN CALIFORNIA'S JANUARY DEER SEASON[1]

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INTRODUCTION

In Southern California approximately 2,000,000 acres of the best deer range usually are closed to entry during regular deer hunting season because of the high fire hazard existing during the drier portion of the year. The topography of this part of the State is characterized by rather flat valleys and abrupt, steep mountains. The low land is of high value resulting from urban, suburban and agricultural development. The brush-covered mountain ranges form watersheds of a critical nature. Destruction by fire of the vegetative cover on these ranges has caused flash floods and soil movements which at times have caused serious economic loss on lands below.

The prohibition of deer hunting in fire closure areas has created problems for the Department of Fish and Game. Heavy pressures by an expanding hunting population have built up on lands open to hunting while the game on 2,000,000 acres of the most productive deer range in Southern California remained unavailable except during occasional years of unseasonable rains. As a result of year long protection, deer from these closed areas increasingly have pushed out to cause depredation to adjacent orchards and vineyards.

In order to work toward a solution of this problem, conferences were started in 1949 with the supervisors of the four national forests who administer federal watershed lands in Southern California. A plan was proposed by which the Department of Fish and Game would maintain checking stations and provide patrolmen if the Forest Service would allow hunters on these ranges during regular hunting seasons. This plan was not acceptable to the Forest Service. It was pointed out that if the restrictions were removed for one class of user, other classes of users (such as hikers, campers, anglers, equestrians, miners) would demand and be entitled to the same privileges. This situation would cause a complete breakdown of the closures. It was stressed that secondary uses of these watershed lands would have to be directed toward periods of low fire hazard, which is limited to three or four winter months. The month of January was suggested as a safe period to plan for a deer hunting season.

As a result of these conferences it became evident that there was no chance for deer hunting in fire closure areas during regular deer seasons, and no assurance of gaining entry to these lands prior to January 1st. In mid-1950, preparations began for establishment of a deer season most satisfactory to all interests concerned.

[1] Submitted for publication May, 1953.

There is a deep-seated but unfounded belief among hunters in California that meat from deer shot during the rut, or several months after, is unfit to eat. A post-rut hunt would be most acceptable from a meat standpoint in May when deer meat is at its prime in Southern California. But a May deer hunting season would find buck antlers in a poor state of development and of little trophy value. Also, May falls in the fawning period, at which time the disturbance of hunting would result in losses of young animals. After an evaluation of all factors, it was decided there would be better public acceptance of a deer season early in January than during any other of the available months. Most of the bucks still retain antlers at this time and the rutting period generally is culminated. It was decided to schedule a two-week season in early January as an experiment to determine what recreational values could be salvaged from deer herds in fire closure areas, from animals which otherwise would remain unharvested.

THE GAME REFUGE PROBLEM

By holding a deer hunting season during the winter period of low fire hazard, the problem of fire closures would be solved. A far less flexible barrier to extensive winter deer hunting in Southern California consisted of the state game refuges which embrace more than a million acres in that part of the State. Because a system of inflexible legislative refuges is no longer considered of value to the State's deer management program, and because of the large acreage of deer range involved, it was decided to wait until all, or most, of these refuges were opened to hunting before proceeding with the experimental January deer hunt. A list of these refuges with the county of location is given below:

Refuge number	*Acreage*	*County of location*	*Year opened*
3C	42,600	Santa Barbara	1947
3D	125,400	Ventura	Part in 1947 Balance in 1952
3H	17,280	Santa Barbara	1947
4A	272,680	San Bernardino	Part in 1947 Balance in 1952
4B	280,960	Los Angeles-San Bernardino	Part in 1947 Balance in 1952
4C	93,440	Orange-Riverside	1947
4D	69,120	Riverside	Not open
4E	51,840	San Diego	Part in 1947 All in 1952
4F	39,040	Ventura-L. A.-Kern	1952
4G	50,000	Riverside	Part in 1947 All in 1952

Some of these refuges had been opened in whole or in part by the Fish and Game Commission in 1947. But a sizable acreage remained closed. Work began in 1950 to convince sportsmen and other interested parties of the need for opening these game refuges to hunting. The absurdity of retaining refuges which, even in their inception, were established not

primarily to benefit game but rather for watershed protection was pointed out. The advantages of flexible hunting closures (with land closed to hunting where needed and only so long as needed) over an inflexible refuge system was explained. The relation of the established refuges to agricultural depredation by deer was demonstrated. The great waste of game that results from locking up vast acreages as inviolate preserves was stressed. As a result of this missionary work, sportsmen's organization petitioned the Fish and Game Commission to allow hunting in the refuge areas in Southern California.

Although the game refuges involved were created by the State Legislature, the power to open or close them has been given by the Legislature to the Fish and Game Commission with other regulatory powers, which are renewable at the end of each two-year legislative period. By mid-1951, a review of requests for refuge openings received by the commission made it appear advisable to lay the groundwork for the winter deer hunt. Letters were sent to the boards of supervisors of counties in which the refuges lay. It was pointed out that there was a possibility the refuges would be opened and it was suggested that existing firearms ordinances be strengthened where needed to afford protection to settled areas. No objections were received from Los Angeles, Orange, Riverside, San Diego or Ventura Counties, but the response from San Bernardino County was contradictory. Residents of some of the settled areas inside Refuge 4A filled the press, and the county supervisors' chamber, with protests. As a result, meetings were called with the Inland Council of Conservation Clubs for the purpose of drafting a proposed ordinance which would afford protection to areas needing protection, but which would not be unnecessarily restrictive. These meetings were attended by representatives of sportsmen's clubs, resorts, the Campers Association, the U. S. Forest Service, the San Bernardino County Board of Supervisors, and the Department of Fish and Game. As a result, a map delineating what was believed to be an adequate restrictive area was prepared and presented to the board of supervisors.

In California, the Fish and Game Commission must hold public hearings in areas involved before issuing an order to open a game refuge. The public hearings in regard to opening seven game refuges (3D, 4A, 4B, 4D, 4E, 4F, and 4G) were held in January, 1952. Little opposition was voiced at the hearings in Los Angeles, San Diego and Ventura Counties; moderate opposition to opening Refuge 4D was encountered in Riverside County; strong opposition to the plan to open refuges was met in San Bernardino County.

As the result of a united front by the sportsmen, the Farm Bureau, the Forest Service, and the Department of Fish and Game all but one refuge were ordered open by the Fish and Game Commission in January, 1952. The exception was the Bighorn Refuge, 4D, the opening of which had the support of only one sportsmen's group. The way then seemed clear to proceed with plans for a January deer hunting season, a program that had been started more than two years before.

THE JANUARY DEER SEASON

Before the Fish and Game Commission permits the taking of female deer in an area it must hold a public hearing. It has been the policy of

the commission to extend such hearings to areas involved in any type of special deer season. Hearings relative to ordering special winter deer season in Southern California were held in the later part of March, 1952, in each of the five counties involved. Only in San Bernardino County was organized opposition encountered. In view of the general acceptance of the proposal by the majority of sportsmen in the southern part of the State the commission ordered the winter deer season set for January 3-18, 1953.

The regulations approved by the commission called for the issuance of a limited number of permits valid only in certain portions of specified counties. The boundaries were drawn as closely as possible to coincide with the fire closure boundaries. In a few instances, for the sake of simplification or to protect winter deer concentrations, it became necessary to exclude some fire closure areas or to include areas which had been open during the regular hunting season. It was believed that the short season and the limited number of permits would protect those areas opened twice from being overharvested.

Sale of Permits

Buck permits for the January season were placed on public sale on a first-come first-served basis at 8 a.m. on Saturday, July 19, 1952. They were distributed as follows:

County	*No. of permits*	*Place of sale*
Los Angeles	2,000	Pomona
San Bernardino	2,000	San Bernardino
Riverside	2,000	Riverside
Orange	500	Santa Ana
San Diego	500	Escondido

In addition, 250 permits were sold to the Marine Corps at Camp Pendleton for distribution to Marine personnel for use on the base.

To assist in the control of deer damage to agriculture, three antlerless deer zones were set up. Permits for antlerless deer were sold in conjunction with the buck tags as follows:

Area	*No. of permits*	*Place of sale*
Glendora to San Bernardino	750 permits	Pomona
Yucaipa to Banning	500 permits	San Bernardino and Riverside
Corona to Murrietta	600 permits	Riverside

People began lining up early the evening before the sale. In all cases the crowd was orderly due to excellent assistance from the Reserve Warden Patrol and to good cooperation from the assembled hunters. Many brought sleeping bags, camp stoves, thermos bottles, and lunches. Some tents and one small sleeping trailer appeared in the lines. In some cases hot coffee and sandwiches were sold by enterprising sportsmen's clubs. There was little complaint and little chiseling. In general the hunters were complimentary about the manner in which the sale was conducted.

The sale started promptly at 8 a.m. The hunters were sorted into buck and doe lines and their applications were filled and checked before they reached the sales desk. As a result the long line of applicants moved forward at a comfortable walking speed, and by early afternoon the lines were gone.

All permits for Los Angeles, Orange, and San Diego Counties were sold on the day of the sale. A few San Bernardino and several hundred Riverside permits remained. These were sold over the counter in the Los Angeles Office of the Department of Fish and Game. They were sold out in less than three weeks.

At the time the hunters purchased their permits, each was supplied with a map which delineated the area for which his permit was valid, and which carried a complete set of regulations.

COUNTY ORDINANCES

The opening of the deer refuges did not cause major changes to be made in the firearms ordinances of Orange, Riverside, Santa Barbara, San Diego or Ventura Counties. About two weeks prior to the hunting season Los Angeles County made minor changes in its ordinances to protect developments at Mount Wilson and in residential areas in the foothills. The pressure of opposition in San Bernardino County was great enough to result in adoption of an extremely restrictive ordinance, which in effect re-established Game Refuge 4A. The adoption of this measure resulted in considerable reaction led by the Inland Council of Conservation Clubs. About two weeks prior to opening of the winter deer season, the ordinance was amended. One week later, the ordinance was amended again. These amendments resulted in opening of some additional areas to rifle hunting. They also led to confusion, not only among hunters but also those who were to assist in enforcement of the law.

MANAGEMENT OF THE HUNT

Every effort was made to keep the hunters informed as to the status of open and closed lands. Despite the last minute additions to the Los Angeles County ordinance, colored maps were prepared by the county. These were made available to hunters by Department of Fish and Game field personnel and by stations operated by the sheriff's office, the Forest Service, and the county department of forestry. Due to last minute changes, current and useful maps of the San Bernardino closure were not available.

Checking stations were set up on the key roads entering the hunting areas. Additional copies of the regulations, maps, and local information were available at these places. These stations were located as follows:

Los Angeles County

1. Little Tujunga Canyon Road
2. Angeles Forest Highway
3. San Gabriel Canyon Road
4. San Antonio Canyon Road

Riverside County

1. Banning—Idyllwild Road
2. Hemet—Idyllwild Road
3. Temescal Canyon Road
4. Santa Rosa Ranch Road
5. Murrietta—DeLuz Road—later moved to Ortega Highway at Elsinore

Orange County

1. Silverado
2. Ortega—later moved to Cajon Pass, San Bernardino County

San Bernardino County

1. Lytle Creek Road
2. High Gear Road
3. City Creek Road
4. Mill Creek Road
5. Cherry Valley—Oak Glen Road

San Diego County

1. Rincon
2. Lake Henshaw

These stations were opened on the day prior to the hunt and were manned continuously from 6 a.m. until 7 p.m. daily for the duration of the fifteen-day season. The personnel manning these stations were, wherever possible, selected for their local knowledge of the country. They were issued written instructions as to their duties and were asked to record all possible expressions of hunters' opinions of the January hunting season.

Regular and Reserve Wardens were sent into the hunting areas to supplement the resident wardens.

FIGURE 1. Successful hunter having his deer tag validated during winter deer season. *Photo by Ted Sierks.*

THE DEER KILL

Due to an oversight in printing the permits, a return address was not provided on the deer tags. It is possible therefore that many tags were not turned in by validating officers and for this reason the known kill may be less than the actual kill. This is indicated by a comparison of the known kill with the data taken from post-card questionnaires sent to participating hunters. A tabulation of the kill as shown by deer tag returns is given:

BUCKS

County	*Permits*	*Total known kill*
Los Angeles	2,000	138
San Bernardino	2,000	210
Riverside	2,000	151
Orange	500	64
San Diego	750	137
Totals	7,250	700

ANTLERLESS

District	*Permits*	*Total Known Kill*
Glendora-San Bernardino	750	211
Yucaipa-Banning	500	95
Corona-Murrietta	600	121
Totals	1,850	427

In order to supplement information on the deer harvest, a post-card survey was made. Cards were sent to every tenth license buyer, a total of 910 being mailed. Of these, 378 cards were returned and tabulated. Of the 378 hunters reporting, 104 (or 27.5 percent) indicated killing deer. Using this percentage as an over-all success ratio for all hunters, it is indicated that the 9,100 license buyers took 2,502 deer. This is well over the 1,153 figure based on tag returns.

In order to determine what hunters thought about the winter deer season, questions were asked on the post cards in regard to condition of deer, palatability of meat, desirability of future winter hunts, and general comments. A tabulation of the results is given below:

CONDITION AND PALATABILITY OF DEER TAKEN IN HUNT

Condition	*Bucks (69)*	*Does (25)*
Good	46 percent (31)	48 percent (12)
Fair	46 percent (31)	48 percent (12)
Poor	8 percent (6)	2 percent (1)
Not given	0 percent (1)	--
Palatability		
Good	69 percent (48)	64 percent (16)
Fair	25 percent (17)	32 percent (8)
Poor	4 percent (3)	4 percent (1)
Untried	1 percent (1)	--

In regard to future winter deer seasons, 78 percent reported in favor, 19 percent were opposed, and three percent did not state their preference.

COMMENTS ON JANUARY SEASON

The January hunting season proved ideal insofar as the weather and the antler condition of the deer were concerned. There were storms during the period, but all three week-ends were warm and sunny. Few deer with shed antlers were reported except from Orange and Los Angeles Counties where an earlier drop is known to occur. Even in these counties the drop was not so advanced as to be a serious obstacle to buck hunting.

At least 80 percent of the hunters interviewed at checking stations and in the field were well satisfied with the January hunting season. It was commonly stated that they enjoyed hunting when the weather was comfortable, when there was no fire hazard, and when there was water in the canyons and springs. Many of the hunters expressed the idea that regular deer seasons should be held in January due to the more pleasant hunting conditions prevailing during that period. A small minority of the hunters contacted did not favor the January hunting season. They complained of "skinny" deer. However, most of these objectors contacted in the field continued to hunt.

The most bitter complaints from hunters revolved around the closure ordinances in San Bernardino County. A few felt that there was collusion between the Department of Fish and Game and the County in this regard.

Another common complaint was about the poor access to hunting areas. The hunters felt that the Forest Service should have taken steps to see that all possible roads were open for public use.

During the regular September deer hunting season, it rained on the opening week end. All the fire closures were opened to all hunters. Many January permit holders were of the opinion that the areas which were to be hunted in January zones should have been kept closed to hunting during the earlier season.

Comments written on the post cards generally were favorable. Those that expressed approval of the hunt were agreed that a special late season was the only way to open fire hazard areas to hunting. Most hunters enjoyed getting out in the cooler weather of the winter season. Those opposing the hunt mentioned the generally poor condition of the deer and the lack of open territory. Many adverse comments were noted about locked gates on access roads, poorly marked areas, and confusion and last minute changes on what lands were open to the hunters. Many thought that there was poor coordination between the Department of Fish and Game, Forest Service, and county boards of supervisors regarding open and closed areas.

The hunter comments on the condition of the deer indicate that most of the deer were in fair to good shape with a small percentage reported as poor. Also, over 90 percent of the hunters considered the meat to be good to fair as to palatability. The post-card results were surprising because of persistent and widespread beliefs among sportsmen that post-rut venison is not of good quality. Cook et al. (1949) in palatability tests on deer and antelope meat taken over the entire year indicated that flavor remained fairly constant throughout the year even during the rutting season. Tenderness was at its peak when deer were considered to be in prime condition, but meat was found to be tender in deer reported to be in only fair condition. There was a general increase in toughness during and immediately after the rut, but not enough to render the animals unfit for eating. The general attitude of most sportsmen in this hunt is best summed up by one successful hunter who commented, "he ain't fat, but he'll sure fit my frying pan."

PLANS FOR FUTURE HUNTS

In view of the fact that field contacts and the post-card survey both show a four to one majority favoring another January hunt, it seems logical to make it an annual program. As a result of action by the 1953 Legislature, six of the nine Southern California refuges, formerly opened by the Fish and Game Commission, have been abolished. Two refuges (4-E and 4-G) have been closed to all hunting, and one refuge (4-F) has been allowed to remain open at the will of the commission until 91 days after adjournment of the 1955 Legislature. A proposal for another such hunt will be presented to the Fish and Game Commission. In general, recommendations for future hunts will closely parallel the pilot model with minor modification in boundaries.

Closer liaison between Forest Service, Game Management, and Wildlife Protection personnel will be necessary in the event of another winter deer hunt. Joint meetings with the Forest Service will be held to coordinate effort, and to assure the opening of as many roads as possible for hunter access.

SUMMARY

Conferences and correspondence with high level Forest Service officials established the fact that harvesting the deer in much of the best deer range in Southern California could not be permitted during established seasons due to the fire risk to valuable watersheds. The only time in which access to these areas can be assured is during a four-month period starting January 1st.

In view of the fact that hunter access could not be guaranteed prior to January 1st, and that the antler drop is generally at its peak in late January, the dates of January 3d to 18th were selected for this experiment. This gave the hunters three week-ends in which to hunt.

The permits were issued on a first-come, first-serve basis at locations within the counties for which they were valid. This was done in order to allow better distribution of the permits. This system worked very well, and was generally satisfactory to the hunters.

During the hunt much confusion resulted in San Bernardino County because of last minute changes in shooting ordinances. Otherwise, the hunt proceeded in a generally satisfactory manner. Complaints were voiced about unnecessarily closed Forest Service roads and there was some concern expressed about allowing a double season on some areas.

A post-card survey was made after the hunt in order to determine the reactions of the participating hunters. Return post cards were mailed to a 10 percent sample of the permittees, and of these 42 percent were returned. The survey indicated that over two-thirds of the hunters thought the meat was good, one-fourth fair, and one-twelfth poor. The survey showed a four to one majority favoring continuance of January deer hunting seasons.

REFERENCE

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A STUDY OF THE FOOD HABITS OF THE RING-NECKED PHEASANT ON IRRIGATED PASTURE IN CALIFORNIA[1]

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INTRODUCTION

One of the results of the state-wide survey of pheasant populations conducted by California Pittman-Robertson Project 22R was the recognition that a heavy concentration of ring-necked pheasants (*Phasianus colchicus*) exists in an area in the vicinity of Oakdale, Stanislaus County, California. Here a pheasant population, inhabiting an area of irrigated pasture land nearly devoid of cereal grains, is equal to the density of birds observed in the Sacramento Valley rice belt, a region considered to be the best pheasant habitat in the State. This density of birds in the Oakdale area in favorable years has been estimated to be 50 birds per 100 acres, which is evidence that the pheasant has established itself with notable success on irrigated pasture land.

In North America the introduction of the ring-necked pheasant has been most successful in the grain producing regions. Fried (1940) conducted a study of the food habits of Minnesota pheasants and found that grains made up 81.3 percent of the total annual food intake. Corn was the predominant item followed in importance by oats, barley, and wheat. Food habits studies conducted in Nebraska by Swenk (1930); in Michigan by Dalke (1937); in Wisconsin by Gigstead (1937); and in Pennsylvania by Bennett and English (1939) all resulted in grain, notably corn, being considered the number one item of importance in the diet of midwestern and eastern pheasants. Cottam (1929) found that of 45 birds collected in Utah, 33 pheasants had eaten grain, of which wheat was the most important, followed by corn, barley, and oats. Ferrel, Twining, and Herkenham (1949) analyzed 179 pheasant crops collected from the Sacramento Valley, California, and found 56.1 percent of the yearly diet to consist of field crops. Rice constituted 38.5 percent of the total food consumed and was found in 61 percent of all crops examined. Barley, wheat, and oats also were eaten. The introduction of pheasants into areas lacking grain farming has met with varying degrees of success, but generally speaking the highest concentrations of birds can be expected in agricultural sections of the country producing grain crops.

DESCRIPTION OF STUDY AREA

Figure 1 is a map of that portion of Stanislaus County lying east of the San Joaquin River showing the location of the areas of high pheasant

[1] Submitted for publication June, 1953. Federal Aid in Wildlife Restoration Act, California Projects W-25-R, and W-22-R.

densities. The area covered by the study is located in Stanislaus County between the Stanislaus and Tuolumne Rivers and situated roughly between the towns of Oakdale, Riverbank, and Waterford. To the north and west of Oakdale, in the vicinity of Valley Home and Escalon, is another area of high pheasant density which, however, is not included in

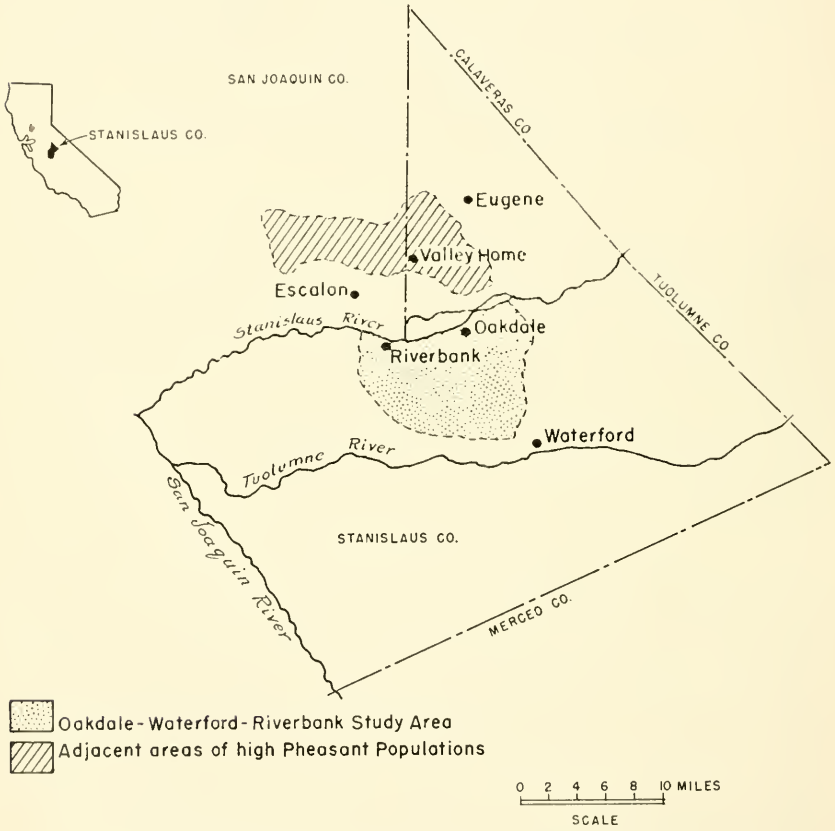


FIGURE 1. Map of Stanislaus County, California, east of the San Joaquin River, showing the location of the study area

this study because rice and other field crops are more prevalent there than in the study area. The land use of the study area is divided as follows: irrigated pasture 60 percent; alfalfa 10 percent; corn (silage) and cereal grains, mostly barley, 10 percent; miscellaneous crops, orchards, vineyards, winter pasture and some rice 15 percent; and waste land 5 percent. There are approximately 40,000 acres of irrigated pasture in this region.

The Oakdale-Riverbank-Waterford study area, where birds were actually collected, is almost solid irrigated pasture land. The other crops mentioned above became numerous only near the perimeter of the area. Recognized as "irrigated pasture" is pasture acreage planted to ladino clover, or ladino clover-alfalfa-grass mixtures (Jones and Brown, 1949). The pasture mixture most widely used is applied 13 pounds per acre and

FIGURE 2. The interspersian af cat-tail and tule-filled drainage ditches with irrigated pasture land furnishes excellent pheasant habitat

FIGURE 3. A heavily weeded drain ditch adjacent ta irrigated pasture and a field af barley provides an abundance of dense cover as well as food

consists of ladino clover 3 pounds, annual rye grass 2 pounds, perennial rye grass 2 pounds, orchardgrass 4 pounds, and alta fescue 2 pounds. The pastures are grazed by livestock and occasionally mowed in the early spring for weed control. The method of irrigation most widely used is by strip checks, the irrigating being done every 7 to 10 days from April to October. It is undoubtedly due to this method of pasture farming and, in part, to the undulating nature of the topography, that an ideal habitat for pheasants has resulted. Accompanying the strip checks are extensive drainage ditches filled with cattails and bulrushes. These ditch bank coverts are heavily vegetated with important sources of food such as mannagrass, watergrass, bristlegrass, panicum grass, knotweed, burclover, and many other weeds. Where drainage is poor, the water at the lower ends of the checks tends to "pound up," encouraging the growth of water-loving plants like galingale, spike rushes, dock, and many of the aforementioned food plants. This interspersion of pasture and heavily weeded drainage ditches and sinks furnishes sufficient cover and an abundance of food.

COLLECTING AND LABORATORY PROCEDURE

Pheasants were collected by shooting in every month of the year so that seasonal changes in diet could be recorded. The collections were made coincidental with the morning and evening feeding periods of the pheasants to insure collecting birds with full crops.

In the laboratory, the crops were removed from the birds and the contents of the individual crops emptied into Petri dishes and oven dried. An individual analysis was made of each crop by separating out and identifying the food items with the use of a dissecting microscope. The quantity of each item was measured in a graduated cylinder to determine the percentage composition of the entire crop. Data were summarized by use of the aggregate percentage method described by Martin, Gensch, and Brown (1946).

RESULTS OF THE ANALYSES

Table 1 is a monthly tabulation in volume percent of all food items comprising 0.1 percent or more of the diet during one or more months, and also includes the yearly diet expressed in volume percent and frequency of occurrence in percent. Table 2 is a supplementary list giving the frequency of occurrence of those food items comprising less than 0.1 percent of the total yearly diet. Figure 4 is a graphical representation of the yearly diet showing seasonal distribution of the principal items of food.

It is evident from an examination of these data that the most important single item of food was ladino clover leafage. It constituted 27.6 percent by volume of the entire diet and was found in 84.2 percent of the crops examined. Although it was eaten every month of the year, highest usage of this food was in the winter months. The consumption of barley was understandably low because of the low acreage of grain in the area. It occurred in but 12.9 percent of the crops and constituted only 6.3 percent by volume of the total diet. A possible source of this barley was supplemental feeding of livestock on the pasture areas. Considering, therefore, that the leafage of ladino clover was the staple item of diet because

TABLE 1

Principal Food Items Eaten by 101 Pheasants
Collected on the Oakdale Study Area, Stanislaus County, California, 1951-1952 *

Common name	Scientific name	Number of specimens												Yearly Diet	
		Jan. 8	Feb. 6	Mar. 8	Apr. 7	May 12	June 7	July 9	Aug. 6	Sept. 10	Oct. 9	Nov. 10	Dec. 9	Vol.% 101	Freq. 101
Mannagrass	*Glyceria fluitans*				30.7	21.2	42.9	11.1	12.5	47.5	trace	trace	0.2	14.1	30.6
Annual bluegrass	*Poa annua*		19.3	trace	24.0	21.3	trace		trace	0.1			0.2	5.4	27.7
Cultivated barley	*Hordeum vulgare*		9.7			16.9	14.3	14.4	22.5	0.7	0.1			6.3	12.9
Wild barley	*Hordeum leporinum*					trace				trace	trace	1.9	trace	0.2	7.9
Rye grasses	*Lolium* spp.					trace	15.1	57.0	42.8	4.1	trace	1.7	trace	9.3	45.5
Crabgrass	*Digitaria sanguinalis*										0.7			trace	4.9
Panicum grass	*Panicum* sp.									trace	0.8		trace	0.1	5.9
Water grass	*Echinochloa curusgalli*	0.7	trace				trace		0.3	10.9	18.4	0.1	trace	2.8	32.7
Bristlegrass	*Setaria geniculata*								12.7	6.9	21.3		trace	3.3	18.8
Grass (leafage)	Gramineae	20.7	12.3	0.3	trace	0.6	trace		trace	trace	trace	trace	trace	2.5	45.5
Valley oak (acorns)	*Quercus lobata*					3.0							9.2	1.2	2.9
Dotted smartweed	*Polygonum acre*									16.2	13.5	37.5	41.4	10.2	16.8
Knotweed	*Polygonum* spp.	3.0	trace	trace					trace		30.8	trace	trace	3.0	15.8
Chickweed	*Stellaria media*		10.5	54.2	21.7	19.1	trace		trace	trace		trace	trace	8.7	30.7
Windmill pink	*Silene gallica*						10.7							0.8	0.9
Ladino clover (leafage)	*Trifolium repens*	67.0	39.3	45.5	23.2	14.1	2.7	17.5	9.0	12.6	4.5	48.4	48.9	27.6	81.2
Black Nightshade (berries)	*Solanum nigrum*											5.5		0.5	0.9
Buckhorn plantain	*Plantago lanceolatum*	trace							trace	trace	trace	4.1	trace	0.3	20.8
Prickly lettuce	*Lactuca scariola*								trace		9.0			0.7	1.9
Forbs (leafage)	Forbs	8.6	8.3	trace	trace			trace			trace	0.6	0.1	1.3	20.8
Insects	Insecta	trace	0.6	trace	trace	3.3	14.3	trace	0.2	1.0	0.9	0.2	trace	1.6	47.5
Snails	Gastropoda				0.4	0.5						trace	trace	0.1	9.9

* NOTE: Monthly diet expressed in volume percent, and the yearly diet expressed both in volume percent and frequency of occurrence in percent. All food items listed are seeds unless otherwise noted.

TABLE 2

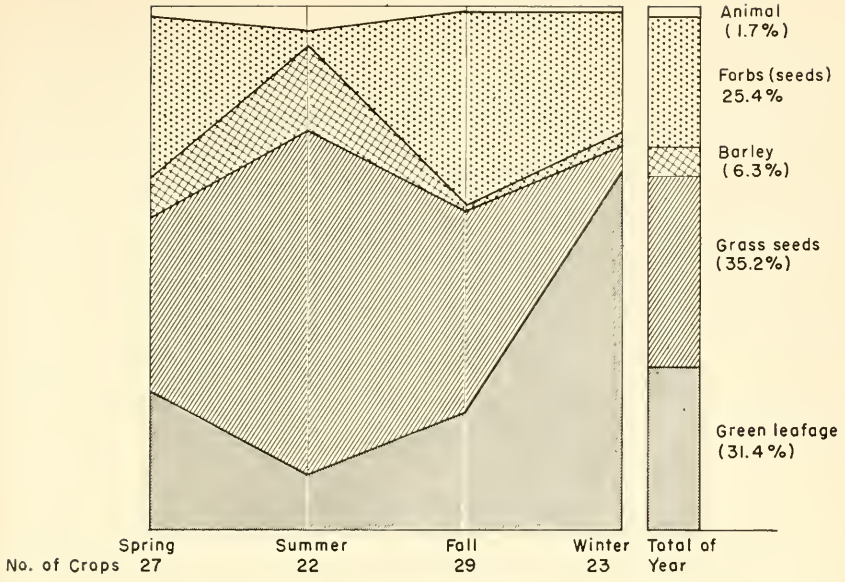
A Supplemental List of Food Items Eaten by 101 Pheasants
Collected on the Oakdale Study Area, Stanislaus County, California, 1951-1952

Common name	Scientific name	Yearly frequency of occurrence*
Bur-reed	*Sparganium* sp.	1.9
Arrow-head	*Sagittaria* sp.	0.9
Rescue Grass	*Bromus catharticus*	0.9
Soft Chess	*Bromus mollis*	3.9
Ripgut Grass	*Bromus rigidis*	0.9
Brome	*Bromus* sp.	3.9
Fescue	*Festuca* sp.	0.9
Dallas Grass	*Paspalum dilatatum*	4.9
Canary Grass	*Phalaris* sp.	1.9
Rabbitfoot Grass	*Polypogon monspeliensis*	3.9
Grass	*Gramineae*	0.9
Galingale	*Cyperus* sp.	7.9
Common Spike-rush	*Eleocharis palustris*	1.9
Wire Grass	*Polygonum aviculare*	1.9
Knotweed	*Polygonum lapathifolium*	0.9
Dock	*Rumex* sp.	9.9
Amaranth	*Amaranthus* sp.	0.9
Red Maids	*Calandrinia caulescens*	5.9
Buttercup	*Ranunculus* sp.	0.9
Mustard	*Brassica* sp.	0.9
Pepper Grass	*Lepidium* sp.	1.9
Mustard	*Sisymbrium* sp.	0.9
Mustard Family	Cruciferae	0.9
Spanish Clover	*Lotus americanus*	1.9
Lupine	*Lupinus* sp.	3.9
Bur Clover	*Medicago hispida*	4.9
Filaree	*Erodium botrys*	0.9
Red-stem Filaree	*Erodium cicutarium*	1.9
White-stem Filaree	*Erodium moschatum*	1.9
Turkey mullein	*Eremocarpus setigerus*	0.9
Morning Glory	*Convolvulus arvensis*	1.9
Amsinckia	*Amsinckia* sp.	1.9
Ground-cherry	*Physalis* sp.	1.9
Aster	*Aster* sp.	0.9
Bur Marigold	*Bidens* sp.	0.9
Star Thistle	*Centaurea* sp.	0.9
Bull Thistle	*Cirsium lanceolatum*	0.9
Brass Buttons	*Cotula coronopifolia*	0.9
Dandelion	*Taraxacum vulgare*	3.9
Chicory Tribe	Cichoreae	0.9
Sunflower Family	Compositae	0.9
Unidentified seeds		0.9
Pill Bugs	Oniscidae	0.9
Spiders	Arachnida	0.9

* Frequency of occurrence in percent on a yearly basis.

it contributed most to the bulk of the food, the seasonal utilization of the seeds of the wild plant foods supplementing this leafage diet is most significant. A total of 58 different species of weed seeds were identified in the crops, but of these only 14 contributed materially to the diet. The seasonal consumption of these seeds is discussed below.

Over the winter months of January and February the consumption of green leafage, principally that of ladino clover and grass and forbs, is at its highest peak. This can probably be attributed to the scarcity of seeds in January. However, in February, the seeds of chickweed and annual bluegrass, which are notable early seeders, made their first appearance. Chickweed constituted 10.5 percent of the February diet, 54.2 percent



Green leafage consisted of ladino clover (88.1%, grass (7.9%) and forbs (4.0%).

FIGURE 4. The seasonal and yearly distribution of the principal food items of pheasants on the Oakdale Study Area, 1951-52

of the March food intake, and continued as an important item of food through May. The seeds of annual bluegrass made up 19.3 percent by volume of the February diet and 24 percent and 21.3 percent, respectively, of the April and May diets.

A substantial part of the spring and summer diet consisted of the seeds of mannagrass. Next to ladino clover it was the most important item of food, having contributed 14.1 percent of the total food intake. Apparently the seeds of mannagrass ripen in April as it made up 30.7 percent of that month's diet and continued to contribute heavily to the pheasant's diet through September when it consisted of 47.5 percent of the food eaten that month.

An important summer food are the rye grasses, whose seeds become available in June and continue through August. July and August were the months in which was recorded the heaviest consumption of rye grass, 57 percent and 42.8 percent, respectively, of the diets. Much of the rye grass eaten can be considered to be "cultivated crops" as it is one of the constituents in the mixture of cultivated seeds planted to irrigated pasture.

Attaining predominance in the fall months are smartweed seeds, appearing first in September and making up over 44.3 percent of the October food. Another 21.3 percent of the October food was bristlegrass seed. Other seeds contributing to the fall diet in lesser amounts were wild barley, crabgrass, panicum, buckhorn, plantain, and prickly lettuce. Black nightshade berries made up 55 percent of one pheasant crop collected in November.

The December diet, although high in ladino clover leafage (48.9 percent), differed from the January and February diets in that the birds apparently were still able to find smartweed seeds which contributed 41.4 percent of the December food. There were three occurrences of water oak acorns in the crops, two in December, and the third in May. Grass leafage, although occurring in 45.5 percent of the crops, made up only 2.5 percent of the total diet; the bulk of the grass having been eaten in the winter.

Animal food eaten consisted of insects, pill bugs, spiders, and snails. The highest intake of animal food was in May and June when insects amounted to 3.3 percent and 14.3 percent of the respective month's diets. This can be attributed to including in the May sample a three-week-old chick, which had 39 percent of its crop contents made up of insects, and a five-week-old chick in the June sample, whose food consisted entirely of insect food. Chick pheasants in the wild normally take considerable insect food until they reach the age of 13 to 16 weeks when their diet becomes similar to the diet of adult pheasants (Ferrel, et al., 1949).

CONCLUSION

It is evident that excellent pheasant habitat exists on the irrigated pasture land in the vicinity of Oakdale, California. Weed lined drainage ditches, sinks and weed patches resulting from this type of farming practice provide abundant natural seeds to supplement the green leafage available from the ladino clover. Also, sufficient cover is present throughout the year. Experienced game bird breeders have recognized that a balanced diet is needed for proper growth, maintenance, and reproduction of penned game birds. These requirements have been met on California state game farms by supplying cereal grains, pellet concentrates, and green foods such as alfalfa and clover. The pheasant in the wild state, provided that it has available a good choice of food materials, will successfully balance its diet naturally (Nestler, 1939). This appears to be true of the pheasants on the Oakdale study area.

Aside from the apparent adequacy of the diet, there are other factors which contribute to the well-being of pheasants in this area. The high rate of nesting success is evident from brood counts in 1950 which showed that 86 percent of the hens observed had chicks with them. It is believed that two factors contribute to this success: (1) irrigated pastures, if mowed at all, are usually mowed only once or twice a year to control weeds; and (2) the frequent irrigation of the pasture strip checks probably concentrates most of the nesting activity on ridges and ditch banks.

The hunting pressure exerted on the pheasant population existing in the study area is less than that experienced in other good pheasant areas of the State. Due to the reluctance of the farmers in the Oakdale area to permit hunting in the vicinity of their grazing livestock, hunting activity is kept to a minimum with the result that the annual harvest of pheasants by hunters in this district is far below that which otherwise would be possible.

SUMMARY

A heavy population of pheasants inhabit the irrigated pasture land in the vicinity of Oakdale, Stanislaus County, California. A total of 101 pheasants was collected from this area for food habits determinations. Ladino clover leafage was the staple item of diet, eaten in every month of the year, and making up 27.6 percent of all the food consumed. However, 66.9 percent of the yearly diet consisted of weed seeds. The predominant weed seeds were those of mannagrass, annual bluegrass, bristlegrass, watergrass, chickweed, and knotweeds. Cultivated crops utilized to a lesser extent were the annual and perennial rye grasses of the irrigated pasture and cultivated barley. It is significant that apparently there are adequate supplies of weed seed the year round to supplement the main diet of ladino clover leafage. The high nesting success and limited hunting pressure further contributes to the success of pheasants in this area.

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A STUDY ON THE POSSIBLE EXTENT OF PREDATION ON HEAVY CONCENTRATIONS OF VALLEY QUAIL WITH SPECIAL REFERENCE TO THE BOBCAT[1]

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INTRODUCTION

The major effort toward habitat improvement for upland game in California has consisted of installation of a watering device known as a "gallinaceous guzzler" in the arid areas of the State where absence or paucity of water was determined to be the limiting factor in the production of game birds. Substantial populations of valley quail, Gambel quail, and in certain areas chukar partridges have been observed about these sources of water, particularly in the late summer months. Conceivably, this massing of game birds around the guzzlers and few remaining water holes might result in their becoming more susceptible to

FIGURE 1. A "gallinaceous guzzler" showing use by California quail

[1] Submitted for publication June, 1953. Federal Aid in Wildlife Restoration Act, California Project W-25-R. The authors wish to express their appreciation to the following California Department of Fish and Game personnel: Mr. Carol M. Ferrel and Mr. Daniel F. Tillotson who as past project leaders were responsible for the analyses of the supplementary stomachs incorporated in this report; Mr. Wallace Macgregor, Jr., who made available much of the field data; and to Dr. Starker A. Leopold of the University of California for his comments on the original manuscript.

predation. Certainly, from all outward appearances these birds would appear to be highly vulnerable to the attacks of predators in such situations.

In order to investigate the possible extent of predation on quail concentrated around water sources, David Selleck, Game Management Supervisor, in May of 1951, requested the cooperation of the food habits laboratory staff in analyzing the stomachs of mammalian predators to be

TABLE 1

Trap Site Data

Trap site	Date	Estimated population		Number of predator stomachs
		Number of quail	Number of chukars	
SP-2	7/11/51	500	150	1
SP-14	7/20/51	300	0	5
SP-15	8/ 5/51	50	0	1
SP-16	8/ 5/51	25	0	2
SP-17	8/ 6/51	300	30	2
SP-21	8/16/51	100	25	5
SP-22	8/23/51	150	30	1
SP-26	8/27/51	30	0	1
SP-24	8/24/51	50	0	3
SP-31	9/28/51	50	0	5
SP-20	8/10/51	0	0	1
SP-30	9/28/51	100	0	1
SP-32	9/28/51	100	25	1
Elkhorn Spring	7/ 8/51	200	100	3
Crocker Spring	7/11/51	300	200	1
Misc. trap sites				3
TS- 1	4/ 8/52	500	0	5
TS- 2	4/ 9/52	300	0	4
TS- 3	4/12/52	300	0	5
TS- 4	5/ 5/52	75	25	2
TS- 6	5/20/52	25	0	1
TS-10	5/31/52	400	500	3
TS-12	6/ 2/52	0	50	1
TS-13	6/ 4/52	200	250	1
TS-17	6/16/52	25	0	2
TS-19	7/ 3/52	50	25	3
TS-22	7/12/52	600	0	1
TS-27	7/15/52	500	0	1
TS-29	8/18/52	400	0	2
TS-30	7/18/52	400	0	1
TS-31	7/18/52	50	0	1
TS-32	7/19/52	50	0	2
TS-35	8/ 7/52	200	0	2
TS-34	7/23/52	20	0	1
TS-36	8/20/52	0	0	1
TS-37	8/20/52	20	0	2
TS-38	8/21/52	400	0	3
TS-39	8/21/52	600	0	2
TS-40	8/23/52	800	0	1
TS-41	8/23/52	300	0	1
TS-42	8/23/52	0	0	1
TS-43	8/23/52	30	0	1
TS-47	9/ 2/52	800	0	1
TS-48	9/ 2/52	250	0	1
TS-49	9/ 2/52	350	0	1

collected in the vicinity of such areas. Walter Frazier, hunter and trapper for the Department of Fish and Game, was assigned the task of trapping on concentration areas with known quail and chukar partridge populations. The predator stomachs were sent to the laboratory for analyses.

The study showed that adult quail are minor prey species, and it is doubtful that predator control is necessary even in concentration areas.

FIELD DATA

The area selected for study lies along the Kern-San Luis Obispo county line in the southeastern corner of that portion of the coastal mountains known as the Temblor Range. It is a semi-arid, lower foothill area of grassland formation. The dominant shrubs are allscale (*Atriplex polycarpa*) and goldenbush (*Haplopappus linearifolius*) with a scattering of California juniper trees (*Juniperus californica*) and interior live oak (*Quercus wislizenii*).

The sites selected for trapping were water holes or springs and guzzler installations. Table 1 is a tabulation of the trap sites showing the relative numbers of quail and chukar partridges present at the time of census, and the numbers of predators which were collected at such sites and from which stomach contents were analyzed. A total of 10,644 sets were made, resulting in the taking of 125 coyotes, 204 bobcats, 47 foxes, 66 skunks, two house cats, 13 raccoons, and 72 badgers. All trapping was done by using scent bait. One hundred fifty-three stomachs were submitted to the laboratory for analyses, but only 93 of these contained sufficient food to render an analysis.

LABORATORY DATA

Upon receipt of the stomach in the laboratory the material was accessioned and prepared for analysis. Each stomach was opened and the contents placed in a graduate to measure the volume of the stomach contents by water displacement. The contents of the individual stomachs were then oven-dried for analysis. The food items were separated and identified macroscopically or by the use of a compound microscope. Each food item was measured by water displacement and the percentage composition of the stomach determined on a volumetric basis. Recorded for each stomach analysis were the numbers of each prey species eaten when more than one animal was distinguishable.

DISCUSSION OF FOOD ITEMS

Table 2 summarizes the food items found in 93 predator stomachs expressed in percentage of food by volume. Table 3 is a summary of the numbers of prey eaten, as enumerated in the stomach analyses. These tables reveal that the bobcat, represented by 53 stomachs, was the dominant predator within the sample obtained.

TABLE 2

Items of Prey Eaten by 93 Predators Collected in the Kern-San Luis Obispo County Study Area Expressed in Volume Percent

Prey	Predators							
	Bobcat	Coyote	Gray Fox	Kit Fox	Striped Skunk	Spotted Skunk	Badger	All Predators
Cottontail	27.2	18.4		25.0				20.3
Jackrabbit	6.0	42.4					20.0	13.2
Lagomorph	5.7	trace			2.8		trace	3.5
Ground squirrel	0.7	0.7					12.4	1.2
Kangaroo rat	30.7	8.2					38.8	21.3
Wood rat	8.9							5.1
Pocket mouse	3.7	11.1		50.0				6.5
Deer mouse	3.3	4.9						2.9
Pocket gopher	3.9						14.6	3.0
Meadow mouse	2.2							1.3
Unidentified rodent		trace	trace		trace			
Deer	1.9							1.1
Pig		4.4						0.9
Valley quail	1.9	5.3			11.1			3.2
Other birds	3.9	trace			11.1		trace	3.3
Reptiles		trace					7.4	0.4
Insects		trace	trace	trace	62.8	trace	1.4	6.1
Other invertebrates				25.0	12.2			2.3
Juniper berries	trace	4.3	100.0			100.0	5.4	4.4
Green grass	trace	0.3						
Number specimens	53	19	2	4	9	1	5	93

TABLE 3

Numbers of Prey Eaten by 93 Predators Collected in the Kern-San Luis Obispo County Study Area

Prey	Predators							
	Bobcat	Coyote	Gray Fox	Kit Fox	Striped Skunk	Spotted Skunk	Badger	All Predators
Cottontail	17	5		1				23
Jackrabbit	4	8					1	13
Lagomorph	4				2			6
Ground squirrel	1	1					1	3
Kangaroo rat	27	8					2	37
Wood rat	5							5
Pocket mouse	8	10		2				20
Deer mouse	10	10						20
Pocket gopher	5						1	6
Meadow mouse	2							2
Unidentified rodent		1	1		1			3
Deer	1							1
Pig		1						1
Valley quail	1	1			1			3
Other birds	5	1			2		1	9
Reptiles		1					2	3
Insects*		6	1	1	9	1	1	19
Other invertebrates*				1	2			3
Juniper berries*	4	2	2			1	2	11
Green grass*	3	3						6
Number specimens	53	19	2	4	9	1	5	93

* NOTE: For insects, other invertebrates, juniper berries, and green grass, the numerical figure represents the number of occurrences of the food item.

Due to the small sample, the food preferances of individual species of predators could not be determined with confidence, and for the purpose of this paper it was decided to consider the effects of predation by all represented predators.

Rodents

The bulk of the prey eaten by the 93 miscellaneous predators consisted of rodents which constituted 41.3 percent by volume of the collective predator diet, a total of 96 rodents being eaten. Rodent species contributing the most to the diet were the kangaroo rat, pocket mouse, and deer mouse. Only three ground squirrels were eaten, which could be attributed to the fact that although the ground squirrels are widely distributed over the area, they are not especially abundant. Wood rats and pocket gophers constituted a small portion of the prey.

Lagomorphs

From field observations it is readily apparent that cottontails are the most abundant of the diurnal prey species. They are scattered in large numbers throughout the range. Jackrabbits, although common in the area, are not as abundant as cottontails. Forty-two lagomorphs found in the stomachs made up 37.0 percent by volume of the diet of the predators. It is considered significant that the bobcats proved to have taken more cottontails than jackrabbits, whereas the opposite was true of the coyotes.

Deer

One bobcat stomach, collected July 7, 1952, at trap site number 22 contained the remains of a California mule deer. Deer are not common in the study area; a few can be found in the higher, more wooded, portions of the range. The circumstances under which this deer was eaten is a matter of conjecture; it could have been carrion.

Pig

The remains of a domestic pig made up 84 percent of the contents of one coyote stomach. The presence of numerous fly larvae indicated that the pig was carrion.

Birds

In all, 12 birds were eaten by the 93 predators, making up but 6.5 percent of the total volume of their collective diet. Six were undetermined passerines, three were valley quail, one was a chicken which had been eaten by a coyote, and two were unidentified birds. No evidence of chukar partridge remains was found in the stomachs. The three valley quail consumed were adult birds, one having been eaten in July by a coyote, and two having been eaten in August, one by a bobcat and the other by a striped skunk. Although the period of study encompassed the nesting season for both the valley quail and chukar partridge, there were no egg remains in the stomachs. However, the likelihood of finding

egg remains in the stomachs of ground predators is extremely doubtful. As pointed out by Glading et al. (1945), egg contents are digested rapidly, and in addition the egg shells, which could be recognized, often are not consumed by the nest predator.

Reptiles

Three reptiles had been eaten. One of these, a fence lizard, was found in a coyote stomach, and the other two, a whip-tailed lizard and an unidentified lizard, were found in badger stomachs.

Insects and Other Invertebrates

The occurrence of insects was noted in all predator diets with the exception of the bobcat. Insects were a major item in the diet of the striped skunk, making up 62.8 percent by volume of their food intake. The Jerusalem cricket (*Stenopelmatus longispina*) was the most prevalent insect eaten, as it constituted 100 percent of the stomach contents for three striped skunks, and 50 percent of another. An additional 12.2 percent by volume of the skunk diet consisted of the remains of trap door spiders (*Bothriocyrtum californicum*). The stomach contents of one kit fox consisted primarily of centipedes (*Chilopoda*) with a trace of mole cricket and insect larvae.

Plant Food

There were 9 occurrences of juniper berries in the 93 stomachs examined. The stomach contents of two gray foxes and one spotted skunk consisted of 100 percent of this vegetable food. There were six occurrences of green grass in the diet of the bobcat and coyote in large enough quantities to indicate that the grass must not have been eaten incidentally.

COMPARATIVE FOOD HABITS OF BOBCATS ON THE STUDY AREA WITH OTHER CALIFORNIA BOBCATS

It is a common belief among sportsmen and many wildlife workers that the bobcat is dangerously destructive to quail. Circumstantial evidence seemingly indicated that large numbers of quail were being taken at guzzler sites and that the bobcat was the principal culprit. An extensive predator control program designed to reduce the numbers of bobcats about guzzlers was thought to be the answer to alleviate this apparent depredation on quail. However, there is considerable evidence based on stomach analyses which shows that adult quail are not important in the diet of bobcats, and that a program of bobcat control would not materially protect quail populations.

Grinnell, Dixon, and Linsdale (1937) cite the results of laboratory examination of 257 bobcat stomachs which contained the following game: quail in 33, deer in 18, brush rabbit in 13, gray squirrel in 7, cottontail in 5, and grouse in 2. McLean (1934) examined 156 bobcat stomachs collected by California trappers from various game refuges and reported finding 5 quail. Dixon (1925) found bird remains to constitute about 4 percent of the total food consumed by 218 California bobcats.

FIGURE 2. A spot map of California shawing county distribution of 166 trapped bobcats

A comparison of the food predilections of the bobcats collected from the study area with those of the bobcats collected elsewhere in the State is made possible by including in this paper the stomach analyses of 166 bobcats collected throughout the State. The localities from which these bobcats were trapped is shown in Figure 2 which is a spot map showing the distribution of trapped animals by counties.

It is evident from an examination of Figure 3, which is a graphic representation of the diet of the study area bobcats as contrasted with that of the state-wide bobcats, that rodents and lagomorphs are the staple items of food for the California bobcat. Those species of rodents which

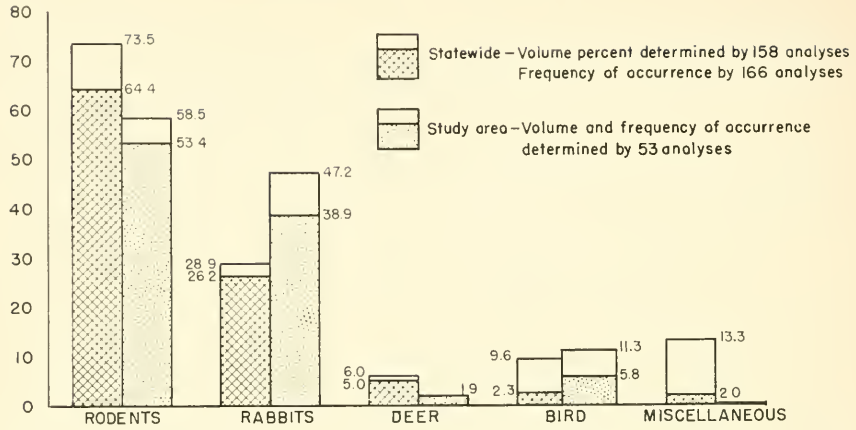

FIGURE 3. Food habits of the bobcat from the study area as compared with that of the bobcat throughout California (complete bar indicotes frequency of occurrence, shaded portion shows volume)

contributed the most to the diet can be seen by referring to the checklist of food items eaten by the additional 166 bobcats (Table 4). The frequency of occurrence of cottontails and brush rabbits in the two comparable diets stresses the importance of these lagomorphs to the bobcat.

Perhaps the most significant result of this study is the relative unimportance of birds in general in the dietary habits of the bobcat. Substantiating this contention is the stomach analyses report published by McLean (1934) and by Dixon (1925). It is evident that adult quail exist as an incidental prey species to the bobcat. Only 3 occurrences of quail were found in the examination of 219 stomachs.

The remains of deer were found in 10 of the stomachs of the 166 bobcats collected throughout the State. Fifty percent of this occurrence of deer was identified as being fawns. There is considerable evidence that adult bobcats are capable of killing deer, and it is possible that fawns may constitute an important source of food in certain areas during a brief portion of the year.

Curiously, neither insect nor vegetable foods appear to be utilized by the bobcat. It is questionable that the two occurrences of insect in the stomachs represented a food item, and the eating of green grass by the bobcats actually contributed little to their total diet.

SUMMARY AND CONCLUSIONS

A total of 93 predator stomachs consisting of 55 bobcats, 19 coyotes, 2 gray foxes, 4 kit foxes, 9 striped skunks, 1 spotted skunk, and 5 badgers were analyzed by the food habits laboratory. This represented a sampling of 529 predators trapped in 1951-1952 from trap sites with a heavy known population of valley quail. Of these 93 predators, one bobcat, one coyote, and one striped skunk had each taken an adult quail. Supplementing these data were an additional 166 bobcat stomach analyses of bobcats collected throughout the State revealing the occurrence of quail in only two occasions.

TABLE 4

Check List of Food Items Eaten by 166 California Bobcats Expressed in Volume Percent and Frequency of Occurrence in Percent

Food items Number of specimens	Volume percent 158	Frequeney of Occurrence percent 166
Mammals		
House cat	1.3	1.2
Belding ground squirrel	1.9	1.9
Golden-mantled ground squirrel	1.0	1.2
Beechey ground squirrel	5.2	7.2
Chipmunk	2.0	2.4
Gray squirrel	3.6	4.2
Pocket gophers	7.6	14.5
Pocket mice	5.0	11.4
Kangaroo rats	2.2	6.6
Heteromyid rodents (undetermined)	0.6	0.6
Harvest mice	trace	0.6
White-footed mice	1.3	3.6
Wood rats	16.8	19.9
Cricetine rodents (undetermined)	0.8	2.4
Meadow mice	14.5	21.7
Norway rat	0.6	0.6
Jumping mouse	trace	0.6
Rodents (undetermined)	1.3	4.2
Cottontail and brush rabbits	14.2	16.9
Jackrabbit	3.0	3.0
Lagomorphs (undetermined)	9.1	9.0
Deer	5.0	6.0
Birds		
Valley quail	0.4	1.2
Red-shafted flicker	0.8	1.2
Spotted towhee	0.6	0.6
Passerines (undetermined)	0.2	3.0
Duck (undetermined)	trace	1.2
Bird (undetermined)	0.3	2.4
Reptiles		
Gopher snake	0.3	1.2
Snake (undetermined)	0.1	1.8
Fence lizard	0.1	0.6
California whip-tailed lizard	0.2	0.6
Lizard (undetermined)	trace	0.6
Miscellaneous Food Items		
Insect	trace	1.2
Green grass	trace	1.2

It is apparent from these data, and from other food habits studies as well, that the staple item of prey for the bobcat and likewise for the coyote in California consists of rodents and lagomorphs. Ferrel and Leach (1953) reported on the examination of 2,222 coyote stomachs that rodents and rabbits constituted 48.8 percent by volume of the food of these coyotes. Quail were found to have occurred in only 10 stomachs. Of the 221 bobcat stomach analyses included in this paper, rodents and rabbits made up the bulk of the prey, quail having been found with but three occurrences. Fifty-three of these bobcats were collected from trap sites with known heavy populations of quail. It appears, there is no evidence to support the widely accepted belief that ground predators, especially bobcats, prey heavily upon adult quail.

Unknown, however, is the possible effects of nest predation by these mammal predators. Glading et al (1945) report 162 valley quail nests under observation at Dune Lakes in 1941-1942 of which 49 or 30.2 percent were broken up by mammal predators. Carnivores are not the only mammals guilty of the destruction of nests. Horn (1938) reporting on 90 quail nests at the O'Neals Experimental Station, mentions that 30 nests were destroyed by ground squirrels, and 17 by carnivores. The present study was not designed to measure nest destruction.

Of possible benefit to quail is the predation on the part of four-legged predators upon the rodent populations. Apparently there exists about these favored watering holes a heavy concentration of rodents which probably accounts for the presence of the predators. There must exist locally a heavy competition for food during certain periods of the year between rodents and quail. For example, the ability of the giant kangaroo rat as a harvester and storer of seeds is phenomenal (Shaw, 1934). Seeds stored by this kangaroo rat, notably those of filaree, would become unavailable to quail. Filaree is considered to be one of the most important foods for quail.

Unfortunately no feathered predators were taken and included in this study. The possibility that there exists in the presence of the Cooper hawk, sharp-shinned hawk, or great horned owl a predator species whose staple diet is quail is not remote. Sumner (1935) mentions the Cooper and sharp-shinned hawks as being the real enemies of quail. Glading et al. (1945) in a study of two nesting Cooper hawks noted that of 64 food items brought into the nest, 32.8 percent consisted of quail. Of the 20 Cooper hawk stomachs analyzed by the food habits laboratory, 5 contained quail remains. Mr. Carl Twisselman, a rancher near McKittrick, is of the opinion that a migration of Cooper hawks occurs in August of every year into the study area. These hawks seemingly remain for a period of a month or two during which time he has observed several incidents of quail being captured, and the presence of the hawks appears to result in the reluctance of coveys of quail to leave the protection of cover. Certainly an investigation of hawk predation under the same circumstances that this study was conducted would be worth undertaking.

As a result of this study it seems evident that adult quail are only a minor incidental prey species to bobcats, coyotes, and probably other ground predators. This casts doubt on the need for predator control to protect quail, even on concentration areas, as in the vicinity of springs or other sources of water.

LIST OF MAMMALS, BIRDS, AND REPTILES MENTIONED IN TEXT

Mammals
- California raccoon (*Procyon lotor*)
- Spotted skunk (*Spilogale gracilis*)
- Striped skunk (*Mephitis mephitis*)
- California badger (*Taxidea taxus*)
- San Joaquin kit fox (*Vulpes macrotis*)
- California gray fox (*Urocyon cinereoargenteus*)
- Coyote (*Canis latrans*)
- House cat (*Felis domesticus*)
- California bobcat (*Lynx rufus*)
- Beechey ground squirrel (*Citellus beecheyi*)
- Belding ground squirrel (*Citellus beldingi*)
- Sierra golden-mantled ground squirrel (*Citellus lateralis*)
- Chipmunk (*Eutamias* sp.)
- California gray squirrel (*Sciurus griseus*)
- Pocket gopher (*Thomomys bottae*)
- Pocket mice (*Perognathus* spp.)
- Kangaroo rats (*Dipodomys* spp.)
- Harvest mouse (*Reithrodontomys megalotis*)
- Deer mouse (*Peromyscus maniculatus*)
- Desert wood rat (*Neotoma lepida*)
- Dusky-footed wood rat (*Neotoma fuscipes*)
- Meadow mice (*Microtus* spp.)
- Norway rat (*Rattus norvegicus*)
- House mouse (*Mus musculus*)
- Jumping mouse (*Zapus pacificus*)
- California jack rabbit (*Lepus californicus*)
- Cottontail (*Sylvilagus auduboni* and *S. nuttalli*)
- California brush rabbit (*Sylvilagus bachmani*)
- Domestic pig (*Sus* sp.)
- Deer (*Odocoileus hemionus*)

Birds
- Cooper hawk (*Accipiter cooperi*)
- Sharp-shinned hawk (*Accipiter striatus*)
- Valley quail (*Lophortyx californica*)
- Gambel quail (*Lophortyx gambeli*)
- Chukar partridge (*Alectoris graeca*)
- Horned owl (*Bubo virginianus*)
- Red-shafted flicker (*Colaptes cafer*)
- Spotted towhee (*Pipilo maculatus*)

Reptiles
- Western fence lizard (*Sceloporus occidentalis*)
- Whip-tailed lizard (*Cnemidophorus tesselatus*)
- Gopher snake (*Pituophis catenifer*)

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EXTENSIONS TO KNOWN GEOGRAPHICAL DISTRIBUTIONS OF SOME MARINE FISHES ON THE PACIFIC COAST[1]

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Of the 22 species discussed in this paper one genus, *Taractes*, and one species, *Euthynnus yaito*, recently captured on the coast of California, have never been reported from the Pacific coast of either North or South America. Another species recently collected at the tip of Baja California, *Nomeus gronovi*, has been recorded only from Panama on our coast. For 10 of the remaining species, the records presented in this paper represent northward extensions, and for nine, southward extensions to the known ranges. These vary from only a few miles (*Typhlogobius californiensis*) to more than 2,100 miles (*Alepisaurus borealis*). Most of the species were caught from the California Department of Fish and Game research vessels N. B. Scofield and Yellowfin.

Dasyatis longus (Garman)

A single ray of this species was taken at San Juanico Bay, Baja California, during the night of April 18, 1948, and six more (three each at Santa Maria and Almejas Bays, Baja California) during the nights of November 26 and 28, 1952. All seven, taken on hook and line from the N. B. Scofield, were of nearly equal length and weight, eight feet and 100 pounds. One of those taken in November, 1952, was a pregnant female containing a single fully-developed young. This foetus was preserved and added to the fish collection of the University of California at Los Angeles and one of the adults was presented, in a frozen state, to Dr. Bruce Halstead, School of Tropical and Preventive Medicine, Loma Linda. Beebe and Tee-Van (1941) give the geographical distribution for this species as Gulf of California to the Galapagos and state that it is known to attain a length of 8 feet 9½ inches and a weight of 102 pounds. The San Juanico specimen extends the known range northward on the outer coast of Baja California some 270 miles.

Rhinoptera steindachneri Evermann & Jenkins—Bat ray

During November, 1952, 34 bat rays were caught by the N. B. Scofield in the Magdalena Bay area, Baja California. Two were collected in two-inch mesh gill nets at Santa Maria Bay during the night of November 26th and the other 32 at Almejas Bay during the night of November 27th (14 in two-inch mesh gill nets and 18 in eight-inch inner mesh trammel nets). Beebe and Tee-Van give the range of this species as Gulf of California to the Galapagos Islands. The Santa Maria Bay specimens extend

[1] Submitted for publication June, 1953.

the known range northward on the outer coast of Baja California approximately 170 miles. Some of these have been deposited in the fish collections of the University of California, Los Angeles, and the School of Tropical and Preventive Medicine.

Myliobatis asperrimus Gilbert—Eagle ray

Two eagle rays were caught by the N. B. Scofield at Almejas Bay, Baja California, during the night of November 27, 1952. One was taken on hook and line in 5.6 fathoms of water and the other in an eight-inch inner mesh trammel net which had been set in five fathoms of water. Beebe and Tee-Van report this species only at Panama Bay. One specimen has been deposited in the fish collection of the University of California, Los Angeles, and the other at the School of Tropical and Preventive Medicine.

Urotrygon rogersi (Jordan & Starks)

A single ray of this species was taken by the N. B. Scofield in a two-inch mesh gill net at San Juanico Bay, Baja California. The gill net had

TABLE 1

Measurements and Counts on Two Alepsisaurus borealis

	Lat. 04° 46′ N. Long. 89° 20′ W. February 17, 1953	10 mi. off W. end Santa Catalina Island September 20, 1952
Measurements[1]		
Standard length	1211	885
Total length	---	1035
Head length	15.1	18.5
Fleshy orbit	2.2	--
Snout length	6.2	--
Maxillary length	10.0	--
Bony interorbital width	2.4	--
Pectoral fin length	17.6	--
Ventral fin length	5.6	7.1
Dorsal base	66.1	--
Anal base	10.8	--
Pectoral base	2.9	--
Tip of snout to dorsal insertion	15.4	17.3
Tip of snout to anal insertion	77.7	--
Tip of snout to ventral insertion	42.3	--
Tip of snout to pectoral insertion	15.9	--
Pectoral insertion to dorsal insertion	7.4	--
Counts		
Dorsal rays	42	34
Anal rays	16	17
Pectoral rays	14	15
Ventral rays	8	8
Gill rakers outer arch, total	26	30
Upper limb	6	5
Lower limb	20	25
Total vertebrae	50	51
Sex	female	female

[1] Standard and total lengths in millimeters; all other lengths expressed as percentages of standard length.

been set overnight on November 24, 1952, in four fathoms of water. Beebe and Tee-Van give the range for this species as the west coast of Mexico and Panama. This specimen, which extends the known range northward some 270 miles on the outer coast of Baja California, has been deposited in the fish collection of University of California, Los Angeles.

Alepisaurus borealis Gill—Pacific lancetfish

On February 17, 1953, a four-foot lancetfish was taken by the N. B. Scofield on a set line which was fished at around 15 fathoms. This capture was made about 290 miles north of the equator (lat. 04° 46′ N., long. 89° 20′ W.) where the depth of the water was over 1,000 fathoms. The set line, baited with dead sardines, had been put out at 6.30 a.m. and was pulled at 2 p.m. The total catch comprised the heads of two other lancetfish (bodies presumably bitten off by sharks), three Pacific sailfish, *Istiophorus greyi*, and 13 sharks. The stomach of the lancetfish contained 81 hatchetfish, *Sternoptyx obscura*, all of which were in excellent condition and ranged from 1½ to 2¼ inches in length. Specific identification of the hatchetfish was verified by Dr. Rolf L. Bolin, Hopkins Marine Station, Pacific Grove. Previously, the Pacific lancetfish had been recorded from northwestern Alaska south to "Monterey, Lower California." Capture of this species just north of the equator represents a southward extension of the range of more than 2,100 miles.

Measurements and counts for the set line lancetfish and a second specimen caught on hook and line 10 miles off the west end of Santa Catalina Island, California, are presented in Table 1. The Santa Catalina Island fish was caught on September 20, 1952, by Mr. M. A. Burson, Los Angeles, who was fishing for albacore with live anchovy bait at a depth of 20 feet.

Paralichthys woolmani Jordan & Williams—Speckled halibut (Figure 1)

Two of these halibut were taken by the Yellowfin in eight-inch inner mesh trammel nets on the night of April 17, 1950. These nets had been set in five fathoms of water near Horseshoe Shoals, Magdalena Bay, Baja California. The catch also included a large California halibut, *P. californicus*. The larger of the two *P. woolmani* was 581 mm. standard length (approximately 28 inches total length), and weighed slightly more than five pounds. Ginsberg (1952) gives the geographic distribution of this species as Cape San Lucas, Baja California, south to Paita, Peru, and states that the largest individual which appears to have been actually measured was 17½ inches in total length. The present specimens not only extend the known range northward on the outer coast of Baja California some 150 miles, but both were larger than the 17½-inch maximum length as stated by Ginsberg. The larger of the two specimens has been deposited in the fish collection of the University of California, Los Angeles.

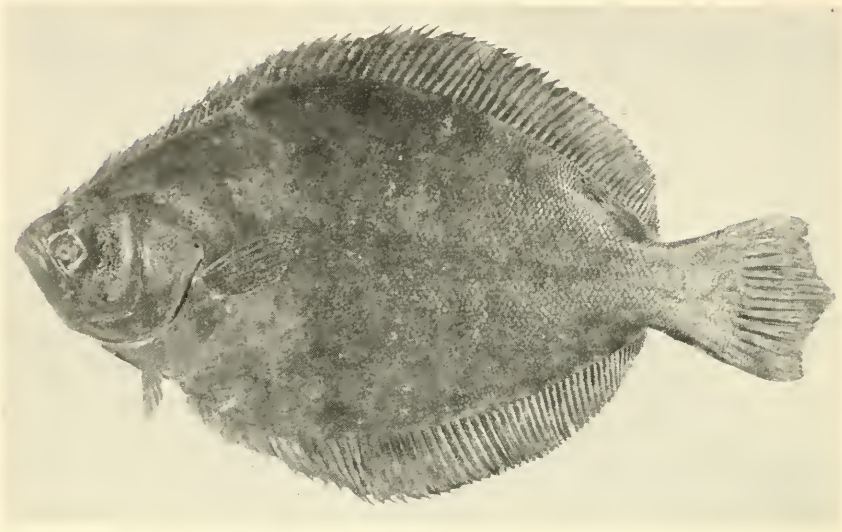

FIGURE 1. Speckled halibut, *Paralichthys woolmani*, 581 mm. standard length. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

Nomeus gronovi (Gmelin)—Portuguese man-of-war fish (Figure 2)

Seven of these small fishes, ranging in total length from two to three inches, were dipped under a light from the N. B. Scofield at Gorda Point, Baja California. The light had been suspended from the stern of the vessel during the night of May 10, 1953, and these small fish were attracted to it. When a Portuguese man-of-war fish would come within the

FIGURE 2. Portuguese man-of-war fish, *Nomeus gronovi*, 39.8 mm. standard length. *Photograph by Herb Phillips, San Pedro.*

beam of the night light, it would lie quite still at the surface of the water with its very long black ventrals expanded. It is said to be one of the most widely distributed and abundant of all pelagic fishes in the tropical Atlantic and Indian Oceans. As many as 10 have been caught in a single scoop of a dip net, all of which were swimming under a single Portuguese man-of-war. This species has also been taken in the Philippines (Herre & Herald, 1950) and once from the Pacific coast of Panama (Meek & Hildebrand, 1925, p. 407). The present specimens extend the known range for this species on the Pacific Coast northward from Panama a distance of over 2,000 miles. In view of the scarcity of these fish in Pacific waters, one of the specimens was cleared and stained and the following counts were made: dorsal XII, 27; anal II, 26; caudal 9-17-9; pectoral I, 21; ventral I, 5 (rays fork near base and appear to be twice as numerous as actual count); gill rakers on outer arch 8+1+15 (upper, center and lower limb); vertebrae 41, 14 precaudal plus 27 caudal including hypural plate; a single row of 20 to 24 conical, inward-curved teeth in each jaw. Most authorities ascribe three spines to the anal fin; however, the stained specimen shows what has been mistaken for a third spine is actually an unbranched ray. The remaining Gorda Point specimens were placed in the fish collection of the University of California, Los Angeles.

Paranth'as ca!anus (Valenciennes)—Southern creole fish

A single adult southern creole fish was taken on hook and line on March 17, 1953, at San Benito Island, Baja California, by the YELLOWFIN. This fish was caught on cut sardine bait in 90 feet of water, the surface temperature of which was 58.1° F. Walford (1937) uses the name of the Atlantic form *P. furcifer* and gives the geographical distribution on the Pacific coast as Cape San Lucas to the Galapagos Islands. The present specimen represents a northern extension of the range of over 450 miles on the outer coast of Baja California. It has been placed in the fish collection of the University of California, Los Angeles.

Dermatolepis punctatus Gill—Leather bass (Figure 3)

A 21½-pound leather bass, 31 inches in total length, was caught on a live mackerel in 120 feet of water off Pescadero Point, Baja California, by Mr. Jack Klug of the boat U & I. This species has been given its common name from the characteristic heavy, leathery membranes between the fin rays. Walford gives the geographical distribution of this species as Mazatlan to the Galapagos; however, it has been taken at Cape San Lucas and in the Gulf of California. The present specimen is believed to be the first definite record from the outer coast of Baja California and extends the range northward from Cape San Lucas some 30 miles. Figure 3 illustrates the general changes in body shape and proportions which take place with age in this species.

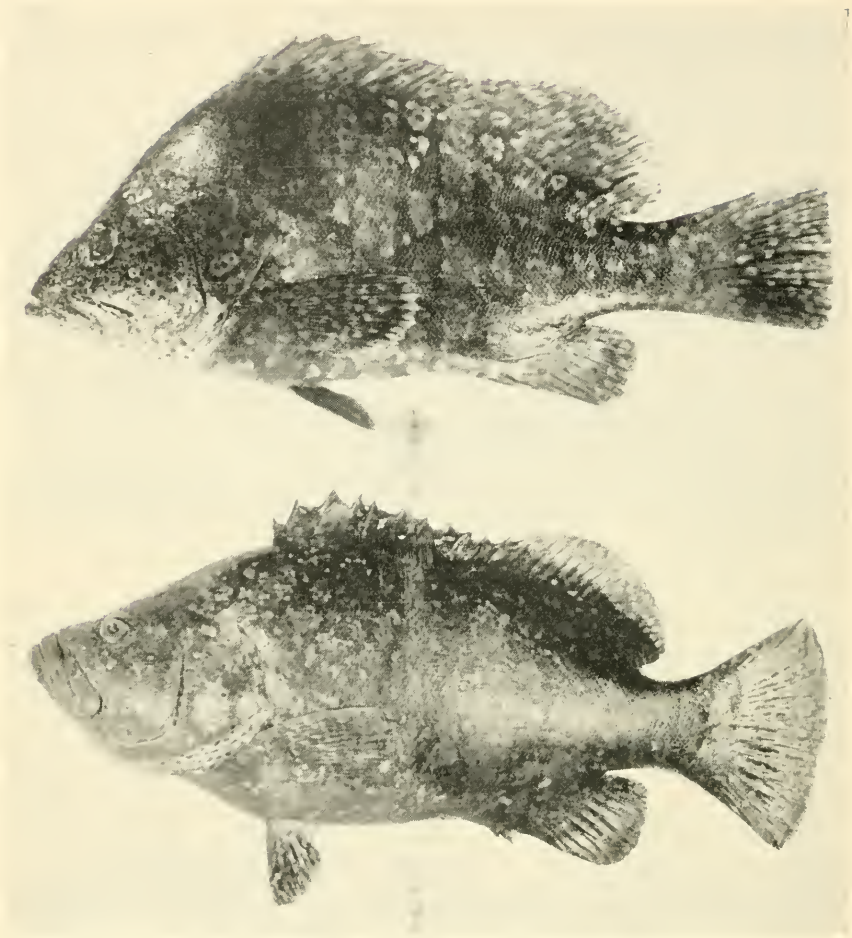

FIGURE 3. Leather bass, *Dermatolepis punctatus*, showing changes in shape between young (about 30 cm.; top figure) and old (about 68 cm.; lower figure) fish. *Top photograph by Herb Phillips, San Pedro.*

Diapterus aureolus (Jordan & Gilbert)

On March 28, 1952, a single specimen of *Diapterus aureolus* was collected with explosives by the YELLOWFIN some two miles off Howlands Bluff, Santa Maria Bay, Baja California. Meek and Hildebrand (1925, p. 594) give the geographical distribution of the species as the coasts of Panama and Colombia; however, personal communication with Dr. Boyd W. Walker, University of California, Los Angeles, who identified the Santa Maria Bay specimen, shows that he has collected *D. aureolus* in the Gulf of California at Mazatlan, the mouth of the Rio Mayo, and at San Carlos Bay near Guaymas. The present collection extends the known range of this small mojarra northward on the outer coast of Baja California some 170 miles.

Icosteus aenigmaticus Lockington—Ragfish (Figure 4)

Two small ragfish were turned over to the California State Fisheries Laboratory for identification during the spring of 1953. The first of these

FIGURE 4. Ragfish, *Icosteus aenigmaticus*, 201 mm. standard length. *Photograph by Herb Phillips, San Pedro.*

(Figure 4) was taken by the boat GIOVANNI in gill nets which had been set over the night of April 23d in 50 fathoms of water, approximately 10 miles south of the San Pedro breakwater. The ragfish and a pelagic octopus, which was also caught at the same place, were presented to the Laboratory by the fishermen Anthony and Nick Cresci. The octopus, a female, was identified by Dr. S. Stillman Berry, Redlands, California, as the third known California specimen of a world wide species, *Ocythoe tuberculata* Rafinesque. In addition to the ragfish and the octopus, the gill nets contained three California barracuda, *Sphyraena argentea*, and several dozen small molas, *Mola mola*.

The second ragfish was caught on hook and line May 17 in shallow water off San Onofre, California, by Mr. Norman Barbre from the boat REEL FUN. There are but two other records of this northern deep-water species from Southern California, one taken near Cortes Bank in 1913 and the second, a 57-inch specimen, taken off San Pedro in gill nets during March, 1921. According to Clemens and Wilby (1946) this ragfish attains a length of seven feet and large specimens have been found commonly in stomachs of sperm whales during certain years. The geographical distribution is generally given as Southern California to southeastern Alaska. Cortes Bank lies approximately 100 miles off San Diego and in latitude is 50 miles south of San Onofre. Therefore, the San Onofre specimen, while not an extension to the north-south geographic distribution of the species, does represent an inshore or coastwise extension of some 40 miles from San Pedro. Both of these ragfish have been placed in the fish collection of the University of California, Los Angeles. Counts and measurements are presented in Table 2.

TABLE 2

Measurements and Counts on Two Icosteus aenigmaticus

	10 mi. S. San Pedro breakwater April 23, 1953	San Onofre May 17, 1953
Measurements[1]		
Standard length	201	252.5
Total length	236.5	288.5
Head length	24.6	22.7
Fleshy orbit	3.5	3.8
Bony interorbital	12.4	10.1
Depth at anal insertion	36.8	29.5
Depth of least caudal peduncle	7.7	5.8
Tip of snout to dorsal insertion	31.8	28.9
Tip of snout to anal insertion	59.2	56.2
Tip of snout to ventral insertion	36.6	31.7
Tip of snout to pectoral insertion	24.1	23.2
Counts		
Dorsal rays	52	54
Anal rays	35	36
Pectoral rays	20	21
Gill rakers, total	16	15
Upper limb	6	5
Center	1	1
Lower limb	9	9

[1] Standard and total lengths presented in millimeters; all other lengths expressed as percentages of standard length.

Taractes sp.—Bigscale pomfret (Figure 5)

On April 22, 1953, Mrs. Fred Olson and Miss Mildred Humborg, while on the beach at Corona Del Mar, California, saw a large fish swimming feebly in the surf. The two women caught the fish by the tail, hauled it onto the beach and transported it to a Newport Beach boat landing

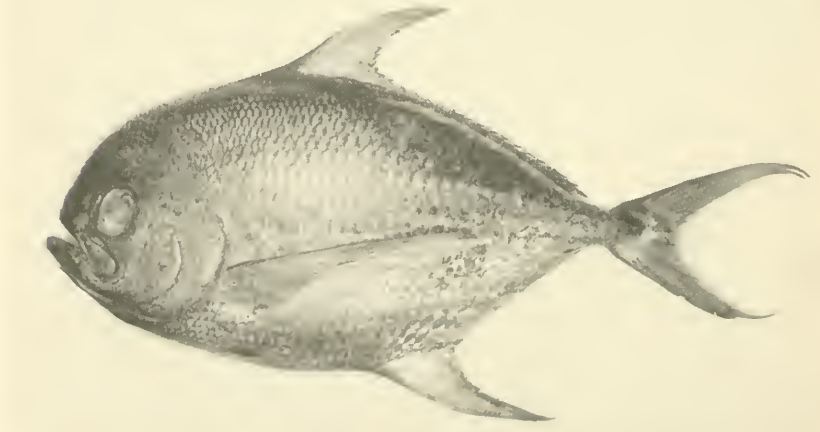

FIGURE 5. Bigscale pomfret, *Taractes* sp., 590 mm. standard length. *Photograph by Herb Phillips, San Pedro.*

where it was preserved in a frozen state. A week later the specimen was turned over to the California State Fisheries Laboratory for identification. An exhaustive search of the literature revealed it to be a member of the genus *Taractes*, and though seemingly specifically distinct, it agrees in many respects with the description of a *T. princeps* (Table 3) which had been taken in 1928 off the coast of Nova Scotia and reported upon by Bigelow and Schroeder (1929). The apparent differences between these fish may be resolved by the capture and examination of a greater number of specimens from both coasts. *T. princeps* was described by Johnson from adult fish 27 and 33 inches long taken at Madeira where it is supposedly common enough to have a vernacular name. The genus *Taractes* has not previously been reported from the Pacific coast of either North or South America.

TABLE 3

Comparison of Corona Del Mar, California, Taractes With Taractes princeps Johnson From Cape Sable, Nova Scotia

	Corona Del Mar April 22, 1953	Cape Sable Jan. 10, 1928[1]
Measurements[2]		
Standard length	590	618
Total length	775	830
Head length	30.1	32.4
Eye diameter		
Horizontal	6.8	6.6
Vertical	8.5	8.4
Snout	9.1	10.2
Maxillary	15.8	14.7
Least suborbital width	2.2	------
Bony interorbital width	12.2	12.9
Distance of anterior nare before eye	4.4	4.7
Distance of posterior nare before eye	1.4	1.6
Length of posterior nare	2.1	1.8
Greatest depth of body	50.2	52.1
Pectoral insertion to dorsal insertion	36.6	------
Pectoral length	42.5	38.2
Ventral length	7.3	7.0
Height of dorsal fin	32.0	28.2
Height of anal fin	33.9	28.3
Tip of snout to dorsal insertion	44.7	------
Tip of snout to anal insertion	60.0	------
Tip of snout to ventral insertion	36.1	------
Tip of snout to pectoral insertion	32.0	------
Counts		
Dorsal	31[3]	III, 32
Anal	25[3]	II, 26
Ventral	I, 5	I, 5
Pectoral	I, 20	20
Gill rakers (functional only)	10	9
Upper limb	2	2
Lower limb	8	7
Lateral line scales	40	43[4]
Scales, vertical series	23	27

[1] From Bigelow & Schroeder (1929).
[2] Standard length and total length presented in millimeters; all other lengths expressed as percentages of standard length.
[3] Dorsal spines and rays not distinguished on Corona Del Mar fish.
[4] Longitudinal series on midline counted on Cape Sable fish.

The Corona Del Mar fish was approximately 30 inches in total length and weighed 18½ pounds. It differed most noticeably from the Nova Scotia specimen in the possession of a lateral line which curves rather gently for two-thirds its length, drops abruptly to the mid-line and continues straight for the posterior third of its length. This lateral line is so poorly defined for its entire length that it could easily be overlooked; however, for the Nova Scotia fish Dr. Schroeder (personal communication, 1953) states, "Both Dr. Bigelow and I have re-examined the 1929 specimen of *princeps* and failed to find a lateral line or any pores." The dorsal and anal fins of the Corona Del Mar *Taractes* are made up of 31 and 25 rays respectively. The first 11 rays of both are scaled nearly to their tips and are in close proximity to each other, forming a high, falcate fin, which is followed by 20 rays in the dorsal and 14 rays in the anal. The bases of these latter rays are connected by a low membrane which is covered with many small scales arranged in irregular series; however, the tips of the rays are free, naked, white in color and appear almost to be finlets. The first two rays of the ventrals are tipped with white, as is the posterior portion of the inside margin of the caudal. The remainder of the fish, except for the pectorals which were pale, was blackish in color when in fresh condition. Between the insertion of the dorsal and anal fins there are 17 major scale rows which are bordered by about three irregular rows of small scales at the base of each fin, giving a total of about 23 rows.

The Pacific coast *Taractes* has been deposited in the fish collection of the University of California, Los Angeles.

Luvarus imperialis Rafinesque Louvar

The louvar, a close relative to the tunas, has been taken at infrequent intervals from most of the temperate seas throughout the world. In all, less than 40 adult individuals have been recorded and these mostly from the North Atlantic and Mediterranean, the Indian Ocean, and the Pacific Ocean off the United States and Australia. On nine occasions, between 1906 and 1949, louvars have been captured along the Pacific coast of North America. All of these have occurred between Santa Catalina Island, California, to the south and Newport, Oregon, to the north. The smallest of these for which a definite measurement is reported was about two feet in total length (520 mm. standard length) and the largest was six feet and one inch in total length. No weight was recorded for the smallest specimen; however, one taken at Pt. Mugu in 1939 weighed only 13¾ pounds. On the other hand, the weight of the six-foot one-inch louvar was reported at 305 pounds.

On December 25, 1952, Mr. George Pal, Hollywood, California, caught and landed a 5½-foot louvar at Acapulco, Mexico. This fish was taken on a trolled feather lure and was landed after a battle of more than an hour and a half. Mr. Pal sent an excellent color transparency of this prize to the California State Fisheries Laboratory for identification. Capture of this specimen at Acapulco extends the known range southward from Santa Catalina Island, California, a distance of over 1600 miles.

An eleventh Pacific coast capture was made the morning of May 17, 1953, by Mr. F. H. Wheat, Wasco, California. Mr. Wheat, while digging clams at the foot of Los Osos Road, Morro Bay, California, noticed a six-foot louvar swimming feebly in the surf and proceeded to grab it

by the tail and drag it ashore. By the time it was sent to the California State Fisheries Laboratory, much of the face and some of the bones of the skull had been torn away from rough handling. Measurements and counts were made as accurately as possible on the damaged fish and are presented here to supplement the excellent detailed data of Bolin (1940). Measurements in millimeters: standard length 1672; head length 440; tip of snout to dorsal insertion 980; tip of snout to anal insertion 950; tip of snout to pectoral insertion 470; tip of snout to ventral insertion 535; ventral length 57; greatest depth 560. Counts: dorsal 13; anal 13 (anterior, falcate portion of dorsal and anal is made up of two rays which are considerably stouter than the rest); pectoral I, 18; functional gill rakers 5 + 11; vertebrae 9 + 13 = 22. Sex: female (with very large, presumably ripe, gonads). Weight: 290 pounds.

Gregory and Conrad (1943) present an excellent discussion of the osteology and evolution of *Luvarus imperialis*.

Euthynnus yaito Kishinouye—Black skipjack

On the night of September 23, 1952, a black skipjack, 361 mm. fork length, was caught inside Los Angeles harbor in a bait net by the boat STANDARD. This fish had been drawn to a light which had been set out to attract bait fishes and was brought to the California State Fisheries Laboratory by the owner of the STANDARD, Mr. M. L. Smith. The dorsal pattern of this fish was not a series of nearly horizontal stripes as is typical of *E. lineatus*, but consisted of a series of oblique, irregular, reticulate bars and spots. Careful examination and dissection in conjunction with a direct comparison to specimens of *E. yaito* from Hawaiian waters by Mr. H. C. Godsil, California Department of Fish and Game, showed a similarity which leaves little doubt concerning the specific identification of the Los Angeles black skipjack. Mr. Godsil will publish his findings in detail at some future date. *E. yaito* has never previously been reported from the Pacific coast of North or South America.

Acanthocybium solandri (Cuvier)—Wahoo

During early November, 1952, two wahoo were caught from the boat FATIMA by Mr. Walter Richards, San Pedro. Both were taken on a trolled artificial squid, one at Moore Bank and the other at Uncle Sam Bank, Baja California. Walford (1937) cites but a single record from the outer coast of Baja California and that from 100 miles north of Cape San Lucas. Uncle Sam Bank and Moore Bank are respectively 250 and 280 miles north of Cape San Lucas and therefore represent a slight northward extension in the geographical distribution of this species.

Hyperprosopon anale Agassiz—Spotfin surfperch

More than a dozen spotfin surfperch were taken in a beach seine by the YELLOWFIN at Blanca Bay, Baja California, on the afternoon of July 22, 1950. Tarp (1952) gives the geographical distribution of this species as San Francisco to Pt. Conception, California. The capture of these fish at Blanca Bay extends the known range southward some 450 miles.

Hypsypops rubicunda (Girard)—Garibaldi

On November 27, 1952, while working to disentangle a fish trap from a rocky reef just inside Hughes Point, Santa Maria Bay, Baja California, the author observed four garibaldi swimming over and around the reef, at times within four or five feet of the surface. The water at this time was calm and quite clear, affording excellent visibility, and there could be no question concerning correct identification of these fish. *H. rubicunda* had been previously reported from San Juanico Bay, Baja California. The Santa Maria Bay sight records extend the known range of the garibaldi southward some 80 miles.

Sebastodes serranoides Eigenmann & Eigenmann—Olive rockfish
Sebastodes dalli (Eigenmann & Beeson)—Calico rockfish

On September 13, 1952, a number of rockfish were caught by the YELLOWFIN 10 miles southeast of Cape Colnett, Baja California. These were taken on hook and line between 6.00 and 9.30 a.m. in water 110 feet deep with a surface temperature of 55.0° F. Four of these fish representing three species (*S. serranoides*, *S. dalli* and *S. vexillaris*) were later identified by Mr. J. B. Phillips, California Department of Fish and Game. The capture of these rockfish 10 miles southeast of Cape Colnett represents a southward extension of the known range from Point San Jose, Baja California, for *S. serranoides* and *S. dalli*, a distance of some 43 miles. *S. vexillaris* had previously been reported from Cape Colnett (Barnhart, 1936.)

Hexagrammos decagrammus (Pallas)—Greenling seatrout

A single greenling seatrout, 247 mm. standard length, was brought to the California State Fisheries Laboratory for identification by Mr. F. Luciene, San Pedro. It had been caught in a lobster trap at the east end of the San Pedro breakwater by Mr. Luciene's boat SCULPIN during the night of January 11, 1953.

On March 19, 1953, two smaller *H. decagrammus* (180 and 173.5 mm. standard length respectively) were sent to the Laboratory by Mr. George McClelland, Santa Monica, California. They had been caught from the Santa Monica pier on hook and line baited with mussels (*Mytilus*). These are the first known records for this species south of Pt. Conception and the San Pedro fish represents a coastwise extension of the range by more than 110 miles.

Zaniolepis latipinnis Girard

A single specimen of *Zaniolepis latipinnis*, seven inches in total length, was taken by the YELLOWFIN 1.5 miles southwest of San Martin Island, Baja California, on September 14, 1952. This fish was taken on hook and line in 120 feet of water. Barnhart (1936) gives the geographical distribution for this species as San Diego to Puget Sound. The present record therefore represents a southward extension of the known range by more than 145 miles.

Typhlogobius californiensis Steindachner—Blind goby

A single blind goby was caught by Fish and Game Warden Jack Bedwell at Rincon Point, Ventura County, California, on April 12, 1953. This goby, 60 mm. in standard length, was about 12 inches beneath the surface in coarse gravel mixed with an overlayer of cobble and large boulders. Previously the blind goby has been recorded from Cedros Island, Baja California, north on the mainland coast to Point Vicente, near San Pedro, California, and offshore at the western tip of Santa Cruz Island. Rincon Point in latitude is slightly more than 15 miles north of the western tip of Santa Cruz Island and over 60 miles in a northwesterly or coastwise direction from Point Vicente. The present specimen therefore represents an extension of the known range on the mainland coast of over 60 miles but an actual northward extension of only 15 miles.

TABLE 4

Latitudes and Longitudes of Localities of Capture (Arranged From North to South)

Locality	Latitude	Longitude
California		
Morro Bay	35° 22.0′ N.	120° 51.1′ W.
Rincon Point	34° 18.7′ N.	119° 23.2′ W.
Corona Del Mar	33° 35.5′ N.	117° 52.0′ W.
Santa Catalina Island (10 mi. off W. end)	33° 30.0′ N.	118° 48.0′ W.
San Onofre	33° 22.7′ N.	117° 34.5′ W.
Baja California		
Cape Colnett (10 mi. SE.)	30° 48.7′ N.	116° 13.0′ W.
San Martin Island (1.5 mi. SW.)	30° 38.2′ N.	116° 05.6′ W.
Blanca Bay	29° 00.5′ N.	114° 40.1′ W.
San Benito Island	28° 18.2′ N.	115° 34.3′ W.
San Juanico Bay	26° 15.0′ N.	112° 28.0′ W.
Moore Bank	26° 05.3′ N.	113° 25.5′ W.
Uncle Sam Bank	25° 37.0′ N.	113° 25.0′ W.
Santa Maria Bay	24° 47.0′ N.	112° 16.0′ W.
Magdalena Bay, Horseshoe Shoals	24° 32.0′ N.	111° 51.5′ W.
Almejas Bay	24° 26.3′ N.	111° 45.1′ W.
Pescadero Point	23° 20.0′ N.	110° 11.0′ W.
Gorda Point	23° 05.0′ N.	109° 33.0′ W.
Mexico		
Acapulco	16° 48.0′ N.	99° 55.0′ W.

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AGE COMPOSITION OF THE SOUTHERN CALIFORNIA CATCH OF PACIFIC MACKEREL FOR THE 1952-53 SEASON[1]

JOHN E. FITCH
Marine Fisheries Branch, California Department of Fish and Game

This is the third report on the age composition of the Pacific mackerel (*Pneumatophorus diego*) catch and covers the 1952-53 season in which some $18\frac{3}{4}$ million pounds of mackerel were landed. The methods of sampling, age determination, and estimation of numbers of fish are the same as those used in the previous reports (Fitch, 1951, 1953), which covered the period 1939-40 through 1951-52.

Table 1 presents the length frequency by age group for the mackerel, from which otoliths were read during the 1952-53 season. Lengths of the fish are given in quarter-centimeters. The 397 fish ranged in age from 0 through VII; of them, 101 or about one-fourth were of age group III and younger, while only four were of age group VI and older.

Table 2 presents the calculated number of fish landed for each age group 0 through VI+, together with the percentage each comprises of the total number. Over 86 percent of the entire season's catch was contributed by but two year classes, 1947 and 1948.

Table 3 shows the number, by year class, of fish landed for each age group 0 through V for the seasons 1939-40 through 1952-53, and Table 4 presents the same information in pounds.

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[1] Submitted for publication June, 1953.

5—83508

TABLE 1

Length of Fish in Quarter Centimeters at Each Age for the 1952-53 Season Based on Otoliths Read

¼ cm.	Age group							
	0	I	II	III	IV	V	VI	VII
88	1							
89	—							
90	—							
91	1							
92	1							
93	—							
94	1							
95	—							
96	—							
97	1							
98	—							
99	—							
100	2							
101	—							
102	1							
103	—							
104	1							
105	—							
106	1							
107	—							
108	—							
109	1							
110	—							
111								
112								
113		2						
114		1						
115		1						
116			1					
117			1					
118		1	1					
119		2	2					
120			1					
121			3					
122			1					
123			4					
124			6					
125			3	1	1			
126			4	2	—			
127			2	2	—			
128			3	2	—			
129			3	3	2			
130			5	4	8			
131			2	4	1			
132			1	3	6			
133				4	8			
134				5	6			
135				4	11			
136				1	7	1		
137				1	6	—		
138				3	12	—		
139				2	13	1		
140				1	18	1		

TABLE 1—Continued

Length of Fish in Quarter Centimeters at Each Age for the 1952-53 Season Based on Otoliths Read

¼ cm.	Age group							
	0	I	II	III	IV	V	VI	VII
141				—	12	2		
142				1	10	2		
143					7	4		
144					14	2		
145					9	2		
146					13	8		
147					5	12		
148					7	10		
149					—	4		
150					3	2		
151					4	10		
152					—	10		
153					—	5		
154					2	6	1	
155						2	—	
156						4	—	
157						2	—	
158						4	—	
159						1	—	
160						2	1	
161						2		
162						—		
163						—		
164						2		
165						—		1
166								
167								
168								
169								
170								
171								
172								1
Sum	11	7	43	43	188	101	2	2

TABLE 2

Calculated Number of Fish Landed for Age Groups 0 Through VI + for the 1951-52 Season. Percentages of Season's Contribution by Numbers and Year Class Are Also Indicated.

	Age group							
	0	I	II	III	IV	V	VI+	Totals
Year Class	1952	1951	1950	1949	1948	1947		
Number of Fish	86,000	46,000	521,000	1,286,000	9,484,000	2,756,000	33,000	14,212,000
Percent of Landing	0.6	0.3	3.7	9.1	66.7	19.4	0.2	100.0

TABLE 3

Number of Fish Landed by Year Class at Each Age Group From 0 Through V, 1939-40 Through 1952-53

Year class	Age group						Totals
	0	1	II	III	IV	V	
1934						5,340,000	
1935					10,570,000	1,443,000	
1936				35,130,000	13,551,000	970,000	
1937			26,540,000	25,261,000	5,121,000	822,000	
1938		25,200,000	69,322,000	25,661,000	5,274,000	1,082,000	126,536,000*
1939	2,960,030	20,793,030	26,454,000	12,698,000	7,133,000	1,616,000	71,654,000
1940	2,313,000	12,507,000	9,204,000	10,156,000	7,712,000	3,328,000	45,220,000
1941	398,000	29,376,000	54,106,000	33,905,000	10,312,000	2,294,000	130,391,000
1942	0	12,462,000	19,017,000	10,259,000	4,661,000	2,019,000	48,448,000
1943	836,000	16,556,000	10,327,000	11,872,000	5,087,000	429,000	45,107,000
1944	0	14,302,000	25,823,000	10,913,000	1,105,000	584,000	52,757,000
1945	556,000	9,330,000	7,980,000	756,000	688,000	72,000	19,382,000
1946	560,000	1,377,000	3,175,000	4,279,000	937,000	218,000	10,546,000
1947	7,181,000	63,330,000	49,255,000	15,826,000	11,127,000	2,756,000	149,475,000
1948	1,061,000	21,818,000	19,228,000	13,871,000	9,184,000		65,462,000
1949	136,000	3,854,000	4,428,000	1,286,000			9,704,000
1950	6,000	1,583,000	521,000				2,110,000
1951	769,000	46,000					
1952	86,000						

* No information available on the 0 age group of the 1938 year class.

TABLE 4

Pounds of Fish Landed by Year Class at Each Age Group 0 Through V, 1939-40 Through 1952-53

Year class	Age group						Totals
	0	I	II	III	IV	V	
1934						6,851,000	
1935					12,141,000	1,885,000	
1936				31,946,000	14,592,000	1,414,000	
1937			19,306,000	22,163,000	7,015,000	1,178,000	
1938		11,578,000	49,762,000	27,249,000	6,651,000	1,499,000	96,739,000*
1939	961,000	11,609,000	21,747,000	12,898,000	9,058,000	2,334,000	58,607,000
1940	853,000	7,564,000	7,809,000	10,743,000	10,139,000	4,809,000	41,917,000
1941	116,000	15,085,000	40,066,000	36,527,000	13,595,000	3,236,000	108,625,000
1942	0	7,912,000	16,208,000	11,453,000	6,225,000	2,863,000	44,661,000
1943	274,000	9,991,000	9,221,000	12,786,000	6,718,000	638,000	39,628,000
1944	0	7,296,000	22,530,000	13,035,000	1,484,000	852,000	45,197,000
1945	158,000	5,627,000	7,601,000	867,000	899,000	100,000	15,252,000
1946	129,000	1,015,000	2,365,000	4,070,000	1,078,000	290,000	8,947,000
1947	1,477,000	29,643,000	32,320,000	14,692,000	12,819,000	4,058,000	95,009,000
1948	248,000	8,612,000	13,591,000	13,327,000	12,583,000		48,361,000
1949	47,000	2,155,000	3,547,000	1,509,000			7,258,000
1950	1,000	802,000	474,000				1,287,000
1951	252,000	34,000					
1952	33,000						

* No information available on the 0 age group of the 1938 year class.

NOTE

ADDITIONAL PACIFIC COD TAKEN OFF CENTRAL CALIFORNIA

A southern extension of the range of the Pacific cod, *Gadus macrocephalus*, into Central California waters was first reported in California Fish and Game, vol. 37, no. 3, p. 351. This was a 25½-inch specimen taken off Point Sur, latitude 36°18′N., about 25 miles south of Monterey Bay. Since that report, four additional specimens have been brought to the Monterey markets by drag boat fishermen working in the Monterey area. Two were taken by Captain F. M. Rhodes; one, 19¾ inches long and weighing three pounds, was taken in December, 1952, and the other, 20¼ inches long and weighing 3.2 pounds, on May 25, 1953. The first was caught by Rhodes while he was operating the dragger Liberty, the second while he was operating the dragger Midnight Sun. Both specimens were taken in about 90 fathoms off Point Sur.

Captain Jack Favalora, operating the dragger St. Mary, captured two specimens on May 28, 1953, while dragging in 80 fathoms just south of Point Pinos, the southern limit of Monterey Bay. These two were not available for measurement, but the identifications were verified by the marketman when shown one of the specimens that had been captured earlier. Another marketman, who had worked in Alaskan waters, also identified the specimens correctly. These specimens were estimated to weigh three to four pounds each, which would place them in a size range of approximately 20 to 24 inches.—*J. B. Phillips, Marine Fisheries Branch, Department of Fish and Game, June 1, 1953.*

IN MEMORIAM

CLARENCE W. CHANSLER

Clarence W. Chansler, fish hatchery foreman, passed away on June 30, 1953, at Fillmore after an illness of about three months.

Mr. Chansler first entered state service as a part-time employee and was a member of the fish car crew in 1920. He received his permanent appointment in 1928, and later was promoted to fish hatchery foreman. He served in this capacity at the Madera Hatchery, Madera County; Yosemite Hatchery, Yosemite Valley; and Fillmore Hatchery, Ventura County. A Marine veteran of World War I, he was active in American Legion affairs. Only one week prior to his passing, Mr. Chansler was presented with his 25-year certificate and pin for continuous, faithful service with the State of California. He is survived by his wife, Agnes, and son, William. Mr. Chansler's fellow employees and many friends in the Department of Fish and Game throughout the State deeply regret his passing.—*Earl Leitritz, Supervisor of Fish Hatcheries.*

RETIREMENT

GEORGE McCLOUD

George McCloud, Assistant Supervisor of Fish Hatcheries, joined the growing ranks of State Fish and Game employees in retirement on May 1, 1953, after nearly 44 years of distinguished service. He first started work at the Mt. Shasta Hatchery on December 24, 1907, at the age of 15, and worked for the State of California in every year since his first employment, except during the year of 1910, when he was employed by the U. S. Forest Service. He was a member of the first crew assigned to Distribution Car 01 when it was put into service on the railroads in 1908. In 1915, when Car 02 was placed in operation, he was assigned to it.

In 1916, Mr. McCloud built a cabin and spawning station at Rae Lakes, located on the western crest of the Sierra Nevada in Fresno County, for the collection of golden trout eggs. The station was located at the highest elevation of any spawning station ever operated in California and perhaps in the United States. The altitude is close to 11,000 feet.

When the Mt. Whitney Hatchery was completed in 1917, George was made its first foreman. In 1918, he was promoted to fish hatchery superintendent in charge of the Mt. Whitney Hatchery and the golden trout operations centered in the Cottonwood Lakes group, Inyo County. It was under his supervision that spawning stations were installed at Rush Creek, Gull Lake, Kirman Lake, Little Walker Lake, Walker River, Blue Lakes, and June Lake. In 1926, he supervised the building and operation of the Fern Creek Hatchery, Mono County, and in 1930 directed the construction of the Alpine Hatchery near Markleeville.

He was transferred from the Mono-Inyo area to the Mt. Shasta Hatchery in 1941, and in 1945 was appointed assistant supervisor of fish hatcheries in charge of Shasta District No. 1, which position he held until the time of his retirement.

His broad knowledge of fisheries problems in California and his vast experience throughout the State made him one of the most valued hatchery administrators in the department.

Having been an exceptional baseball player during his younger days and an ardent fan throughout his life, George has moved to Sacramento, where he will be able to sit in regularly during the summer ball games. He now resides at 2212 W St.

The best wishes of the entire department go to him on his retirement. —*Earl Leitritz, Supervisor of Fish Hatcheries.*

REVIEWS

Fresh-Water Invertebrates of the United States

By Robert W. Pennak; Ronald Press Company, New York, 1953; ix + 769 p.; 470 figures; $14.00.

Students and workers in all branches of fresh-water biology will welcome this well-illustrated book with its balanced discussion of all the major fresh-water groups and with keys to the genera and in some cases species. Nearly 35 years have passed since the publication of "Fresh-Water Biology" by Ward and Whipple, the only other reasonably complete reference on the fresh-water invertebrates in the English language. During that time, our knowledge of these groups has increased greatly and the taxonomy of many of the groups has been changed drastically.

The style of this book is fresh and new, so that it is more than an up-to-date version of the older standard reference. The most striking difference lies in the greater amount and the organization of the general discussion or text material on each group, so that the book lends itself very well for use as a text for teaching courses on fresh-water invertebrates, while preserving its standing as a source book on the same subject. Typical chapter headings, where applicable, are as follows: general characteristics, special structures, locomotion, physiology, skeleton, musculature, respiration, feeding, nutrition, digestion, excretion, reproduction, behavior, ecology, succession, dispersal, encystment, geographical distribution, taxonomy, collection, preservation, culturing, and economic importance.

For a book to cover so large a field as both a text and reference requires some rather strict limitations. As the title indicates, only those genera occurring in the United States are treated and the algae, larger aquatic vegetation, and the aquatic vertebrates, which were covered by Ward and Whipple, are also omitted. However, this omission will not be felt very keenly, since much of the material is covered by separate books such as the "Fresh-Water Algae of the United States" by Smith. Also omitted are the parasitic cestodes, trematodes, and nematodes, which although they occur in fresh water, are seldom found in the free-living state.

Further limitation and simplification was accomplished by submitting a check list of 450 genera of free-living Protozoa to eight protozoologists, with the request that they strike out the 150 genera least likely to be encountered in field collections. As a result, only 303 genera are keyed.

In general, the keys are carried only to genera, but in the case of certain groups whose taxonomy is quite stable or which are small, the keys have been carried to species. With the addition of the text material this results in considerably greater page per species coverage for smaller groups (sometimes exceeding one page per species) than for the larger groups. However, this does not seem like overemphasis, since there is usually greater interest in the major taxonomic groups with but few fresh-water representatives.

Of the 706 pages covering the discussion of the different phyla, 345 pages and 22 chapters are devoted to the Arthropoda. One chapter each is given to a general discussion of the Crustacea and Insecta, with eight chapters to cover major subclasses or orders of Crustacea and 11 chapters to cover each order of aquatic insects. Only those forms which actually live in the water are keyed. If the adults or pupae are not found in the water, they are sometimes mentioned in the text but are not keyed. The families of the orders Hemiptera, Coleoptera, and Diptera are discussed individually.

The introduction contains an interesting section on the origins of fresh-water fauna and a section on atypical fresh-water habitats. Appendix A contains photographs and descriptions of the most commonly used field and laboratory equipment for collecting and preserving aquatic invertebrates. Appendix B lists various reagents and solutions.

The work is well illustrated with 470 figures. Most are line drawings, but a large number of excellent photographs is included. Many of the figures consist of 10 to 20

smaller drawings. They have been well selected from many sources. Some are redrawn and some original. A very few are of inferior quality. An example is Figure 378, of the aquatic beetle *Ochthebius*. The division between the head and thorax is omitted, while the frontal suture is exaggerated, so that the eyes appear to be on the thorax. Also, the transparent hind angles of the thorax are omitted, and the drawing is not square with the page.

A number of references is included at the end of each chapter. About one page with 30 to 40 references per chapter seems to be the average. These include classic and recent works on taxonomy and other aspects of the group and seem entirely adequate should one wish to find references with which to carry the identifications to species when only generic keys are contained in the book.

The role of an author in the preparation of a book of this magnitude, as Dr. Pennak states in the preface, consists largely of arrangement, organization, and selection from a very large mass of published information. He is dependent upon the large number of specialists to whom he submitted the various sections for criticism to advise him of any bad selections. Similarly, the reviewer is seldom able to make detailed criticisms of more than a few sections.

In the lower phyla, the coverage of those groups with which the reviewer is fairly familiar leaves little to be desired. The portions of the text dealing with those groups with which he is less familiar are well illustrated and presented in an interesting manner, so that it was a pleasure to read them. However, in the chapters on the Insecta, with which the reviewer is more familiar and of which many of the larvae are unknown or have not been associated with the adults, it was not hard to find errors. The aquatic larva of the beetle *Ectoparia* in the family Psephenidae forms a typical example. This has erroneously been identified as the larva of *Helichus* (Dryopidae) by previous American authors and most European authors. However, its true relationship has been pointed out in European literature. Unfortunately, this error has been perpetuated on Page 616 and in Figure 380 A.

Despite the fairly large number of such inaccuracies, which may readily be detected, it may be said without qualification that the acquatic insect portion represents the best illustrated and most usuable and comprehensive single work on the aquatic insects that has yet been published in the English language.—*Harry P. Chandler, California Department of Fish and Game.*

Fundamentals of Limnology

By Franz Ruttner; University of Toronto Press, 1953; xi + 242 p., illus. $6.50.

This translation is of the second German edition (1952) and was made by F. E. J. Fry and D. G. Frey. It is divided into two general parts, the first of which is a discussion of water as an environment and the second a discussion of aquatic biotic communities.

The general impression given by this book is one of directness. This is very evident in the section on dissolved substances, which, although a difficult one, is treated adequately and without the irrelevancy found in other texts. Because limnology is a complex of physical and biological factors it has been difficult to find a book that would show the interrelationships of these constituents in a clear and integrated way other than a series of more or less unrelated subjects. Ruttner has achieved this and his text is easily understood.

One disadvantage to Americans of Ruttner's book is the fact that most of the waters and organisms used as examples are European or from areas other than the western hemisphere. Very few of the references in the bibliography are available to most Americans nor are they as plentiful as they could be. A useful table of German-English equivalents is included as is a rather complete glossary of technical expressions.

Disregarding the several relatively minor disadvantages listed above, this writer is inclined to agree with the translators and say this is probably the best book presently available on the principles of limnology.—*J. B. Kimsey, California Department of Fish and Game.*

Resource Conservation: Economics and Policies

By S. V. Ciriacy-Wantrup; University of California Press, Berkeley and Los Angeles; 1952; 395 p., $6.50.

The scope of this book includes both inert and organic resources—timber, big game, marine fisheries, oil, coal and hydroelectric power. As implied in the subtitle,

the planned use of any resource lies in the province of business management, and it is this aspect of economics that forms the subject matter. The need for conservation has been with man since historic times, for, always, when resources are used carelessly, impoverishment follows unless suitable protective measures are taken. Preventing depletion of resources has been further complicated in contemporary times by three new factors. These are, says the author, a professor of agricultural economics at the University of California, new technological techniques, population growth, and changing social institutions. These factors necessitate the economic analysis of conservation policies.

The greater part of the book covers an analysis of the economic forces and social institutions which affect policies for resource use. Because the book is written for an audience with varying experience in economic analysis, both general and technical language is used. Several chapters are devoted to the definition of technical terms used in conservation. These chapters also introduce a discussion of the forces affecting business enterprise of individuals as well as the larger groups composed of corporations or nations. In the last part the author describes the formulation of conservation policy and presents critiques of the objectives of that policy.

The text is easy to follow. References are those obtainable in a large library, and the index is well designed. Any reader will be better equipped to appraise public programs for conservation and will have an increased appreciation of the significance of research and management. Because of its excellent presentation of concepts fundamental in wildlife economics, *Resource Conservation* will form a basic trilogy with *Game Management* and *The Land and Wildlife.*—*R. L. Eberhardt, California Department of Fish and Game.*

A Herd of Mule Deer

By Jean M. Linsdale and P. Quentin Tomich; University of California Press, Berkeley, California, 1953; 567 p., 174 fig., $8.50.

As stated in the preface, this report seeks to explain the place of deer (*O. hemionus columbianus*) in the biology of the Hastings Reservation. This natural history reservation, located 25 miles southeast of Monterey, California, has been free from artificial disturbance since 1937. On this wild area and adjacent lands, observations on free, wild deer were made by Linsdale, Tomich and others, mostly between the fall of 1937 and that of 1950. This book reports their findings, along with much of the field notes upon which the findings are based. The treatment is divided into chapters on structure, communication, mannerisms, relations to other animals, habitat, activity, food, reproduction and population.

Those interested in the management of deer will find much of value in this volume. A reading of the last six chapters, especially, will not only yield additional confirmation of findings reported elsewhere (such as the affinity of deer for rather small home areas, deer activity peaks in early morning and late afternoon, deer preference for green grasses and forbs in late winter and early spring, the eating of snow as a source of water, sexual pursuit of does by yearling bucks, dependence of deer for food mainly on particular parts of only a few plant species), but the reader also will glean findings of value in deer management not so well known (viz. that fawns are several months old before regularly accompanying does to water, that most of the deer breeding on the Hastings area occurs in October with the fawns born in May, that deer avoid direct sunlight on warm days).

In the face of the intensity, the continuity, and the long period of study, it is regrettable that the observers did not pay more attention to population dynamics. With their interest centered chiefly on individual and small group behavior, an opportunity to determine herd production, mortality, and survival rates was missed. It is true that the reader can piece together a fragmentary picture from the reported findings. But too often this attempt is frustrated, as for instance when one reads that there was a ratio of 145 fawns per 100 does in June, 1949, but reads further to find that does without fawns were not included in the count.

Because of the scope of the study, there is no information on incidence of breeding in yearling does, percentage of yearlings in the doe herd, period and cause of greatest loss of fawns, the changing herd composition from month to month, the net gain or loss in the herd in a year.

The method of presentation of the material in this book will discourage the less patient reader. The profusion of specific field notes tends in spots to outrank and overshadow the findings which they support. While the inclusion of such detail

offers the possibility of new and different interpretations in the light of fuller knowledge at some future date, it is most probable that the men who made the study, and who were aware of the full background as it existed, and as it changed, from day to day, were in the best position to analyze and interpret the data, and might well have presented it in a more concise and readable manner.

Despite such criticism, however, this reviewer believes the authors did what they wanted to do, and did it well. Those interested in the biology of the Columbian black-tailed deer should read this book.—*William P. Dasmann, California Department of Fish and Game.*

Advanced Fly Fishing

By Eugene Burns; The Stackpole Co., Harrisburg, Pa., 1953; xiii + 268 p.; photographs by Clyde Childress; drawings by Firman Bradway. $7.50.

Eugene Burns has written an interesting and useful book on fly fishing for trout. It is easy to read; the explanations are clear; the diagrams and photographs are excellent. The general thesis is that "the difference between taking trout on a fly and not taking them is slight." The book is designed to explain the refinements in tackle and methods which will make the difference. In doing this Burns explodes some theories and he proposes some new ones, which other men will probably try to explode.

Most, if not all, of the chapters are derived from individual articles which originally appeared in outdoor magazines. While there is an attempt to tie the chapters together by cross references, the book suffers from the fact that each chapter is still an entity. The same names (well-known anglers) and allusions to the same set of circumstances appear time after time. For example, we hear at least six times in six different chapters that Burns was once a ranger on the Gray's River in Washington.

Many items of tackle are described by trade name, together with the name of the manufacturer, and a number of resorts mentioned by both name and address. This is useful to the reader, of course, as well as being good advertising.

The book is of special interest to westerners. Streams such as the Gallatin, the Yellowstone, and the McKenzie, California's own Klamath, Pit, Feather, and Rising Rivers, and the great anglers of these waters are described.—*Wm. A. Dill, California Department of Fish and Game.*

Woodsmoke

By Ellsworth Jaeger, The Macmillan Company, New York, 1953, XI + 228 p., illustrated. $2.95.

This little book brings out the author's long, outdoor experience and his years of studying Indian lore and methods.

Like so many books and publications written by easterners, we find an almost empty void in any reference to our own far west and Pacific Northwest. The Navajo country of Arizona is his westernmost source. He gives nothing of the sweathouses, fish and meat smoking and other activities of the Indians in the far west and Pacific Northwest. Because of either the high humidity or extreme dryness, the smoking of fish and meats are definitely different.

As a whole, the book has many excellent suggestions and is definitely useful.

Chapter two on "Indian Larnin" is most interesting but one has a feeling of incompleteness. This is perhaps due to an effort on the author's part to keep the book small.

Chapter three on "Stalking, Lures and Calling" is one of the three best in the entire publication.

The syllablizing of the calls of various birds and animals is good on the whole, but he could have stated more often that calls were whistle-like or voice-like which would have made it much easier for the beginner.

The personnel of this department who worked with waterfowl all agreed they had never heard Lesser Snow Geese tinkle, but that it sounded more like a small dog after his tail had been stepped on. They also agreed that a drake Pintail says whirp, quirp or pwilp but not qua. These are of course the tricks of the human ear and the human effort to put the calls into human syllables.

Chapter four on "Fishing" is on a par with third, with some excellent pointers for the beginner. However, as mentioned above, the author's failure to cover the far west and Pacific Northwest shows up in no mention of methods of capture or species

of any of the Pacific salmon which are so important in that region. He fails to mention the pitch pine fishing torch used by western Indians when spearing fish at night.

Chapter five, on "Fire," is excellent and well worth while.

Chapter six, on "Shelter," is the best of all in that it covers shelter possibilities in almost any circumstance, except on the open plains with no snow or tarpaulin to shield one from frigid winds.

Chapter seven, on "Camping Tricks," is good but here again is the feeling of incompleteness, probably due to the author's attempt to hold down the size of the book.

The last chapter, on "Ax Craft," is interesting, if short. Somehow at the very last he got off on planting of seedlings and reforestation. The whole book is well illustrated by the author's most excellent drawings which depict his points of demonstration very carefully.—*Donald D. McLean, California Department of Fish and Game.*

On Eastern Empidonaces With Particular Reference to Variation in E. traillii

By L. L. Snyder; Royal Ontario Museum of Zoology and Palaeontology, Toronto, Canada, 1953; 26 p., 4 figs.

This is another in the series of scientific publications by the above museum dealing with technical questions. This is primarily of use to the taxonomist and advanced bird student. The material is well put together, thus following the pattern of others in this series which now numbers 35 such contributions.—*Donald D. McLean, California Department of Fish and Game.*

Studies of the Food Habits and the Habitat of Moose in Ontario

By Randolph L. Peterson; Royal Ontario Museum of Zoology and Palaeontology, Toronto, Canada, 1953; 49 p., 7 figs.

This bulletin is the 36th in the series, which includes several on moose by the same author. It reports the results of a study of the habitat and food habits of this animal principally as it occurs on St. Ignace Island in northern Lake Superior. The findings are compared with those of the earlier study on Isle Royale in the southern portion of that lake.

The study included direct field observations at all seasons, analysis of stomach contents of 26 moose taken throughout the year, analysis of the conifer contents of 1,055 pellets from 211 group samples, and feeding experiments in the vicinity of salt-licks. The composition of the vegetative cover was determined from 1,000 sample plots.

The studies indicate that "the actual amount of each food species which moose will consume is correlated and interrelated not only with palatability and availability of that species, but also with the presence, availability or absence, in any given area, of all other food plants of various palatability levels." In the discussion, Peterson states that the failure of low populations of moose to increase appears to be a result of a low rate of reproduction correlated with food supply. "A great quantity of poor foods or of only two or three species apparently will not maintain a healthy population."

Peterson's paper is a valuable addition to the literature on moose.—*William P. Dasmann, California Department of Fish and Game.*

Possums

By Carl G. Hartman; Univ. of Texas Press, Austin, 1952; xiii + 174 p., 104 black and white plates; $6.

Dr. Hartman is a zoologist and physiologist who reports the results of his many years of assembling authenticated and fabled facts concerning marsupial life. In the introduction he refers to this writing as a "* * * not too technical or too serious account * * *".

The book includes 22 chapters, an appendix and an extensive bibliography. The subject matter includes large quantities of historical matter and fables relating to marsupials, with abundant quotations and illustrations from early-day publications. This material is certainly interesting, but very nearly dominates the book. There is a chapter on hunting, one on recipes for cooking, and an appendix titled "Possum Rhymes and Folklore."

Life history and behavior of opossums are treated rather generally with the exception of embryonic development, birth, and marsupial gestation. The six chapters dealing with these matters constitute the backbone of the book.

A series of excellent photographs depicts stages of embryonic development from conception to birth 12 days and 18 hours later. The process of parturition, the trip to the pouch by the young and their establishment therein receive much detailed discussion. These matters have been the subject of wild speculation through the years and many false theories have been propounded up to present times. Hartman presents accurate observational data that show conclusively what actually occurs.

Dr. Hartman's own work on the reproductive phases and his analysis of that of other investigators leaves no question that he is primarily a competent scientist rather than a historian.

The contribution of this volume to science is contained almost entirely in the chapters on reproduction. Aside from this the book is well written and affords interesting reading through the varied subject matter.—*Fred L. Jones, California Department of Fish and Game.*

REPORTS

FISH AND GAME CASES

April, May, June, 1953

Deer violations	55
Waterfowl violations	26
Upland bird violations	53
Inland fishing violations	572
Ocean sport fishing violations	224
Commercial fishing violations	36
Violations for having loaded gun in a car	96
Violations for trespass on cooperative areas	17
Violations for angling without a license	521
Violations for hunting without a license	47
Miscellaneous	117
Total	1,764

Fines Imposed

April, 1953	$15,462.00
May, 1953	16,549.00
June, 1953	23,620.50
Total	$55,631.50

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printed in CALIFORNIA STATE PRINTING OFFICE
83508 7-53 8M

ANNOUNCEMENT

The California Department of Fish and Game is changing publication of *Outdoor California* from a weekly release to a monthly bulletin which will contain information on conservation problems and material of current interest. A copy of the first issue is being mailed to each subscriber to *California Fish and Game*.

California Fish and Game will continue as a quarterly, but with increased emphasis on technical reports and correspondingly less emphasis on popular and semitechnical articles.

Because of increased costs, the subscription lists for both publications will be limited. Current subscribers to *California Fish and Game* will, however, be retained on the list for one—but not both—of the publications as long as they renew annually. Those renewing for 1954 must indicate on the postcard which publication they wish to receive.

Applications for new subscriptions can be considered only from persons who can make professional use of the journal and from libraries, scientific institutions and conservation agencies and groups.